Appendix A: Wilderness Minimum Requirement Guide

ARTHUR CARHART NATIONAL WILDERNESS TRAINING CENTER

MINIMUM REQUIREMENT
DECISION GUIDE

“. . . except as necessary to meet minimum requirements for the administration of the area for the purpose of this Act.”
– Wilderness Act, 1964

Instructions and Worksheets for the Minimum Requirement Analysis
for Actions, Projects, and Activities in Wilderness

The Minimum Requirement Decision Guide is designed for wilderness administrators to effectively analyze proposed actions to minimize negative impacts to wilderness character and values. It assumes a basic knowledge of the Wilderness Act of 1964, agency policies, and specific provisions of the wilderness designation legislation for each unit. This guide is suggested for wilderness administrators for the four federal land management agencies, the Bureau of Land Management, the National Park Service, the U.S. Fish & Wildlife Service and the U.S. Forest Service.

Section 4(c) of the Wilderness Act of 1964 prohibits certain activities in wilderness by the public, and, at the same time allows the agencies to engage in those prohibited activities in some situations. Section 4(c) states:

“… except as necessary to meet minimum requirements for the administration of the area for the purpose of this Act (including measures required in emergencies involving the health and safety of persons within the area), there shall be no temporary road, no use of motor vehicles, motorized equipment or motorboats, no landing of aircraft, no other form of mechanical transport, and no structure or installation within any such area.”

Therefore, unless a generally prohibited use is allowed by specific unit designation, most of these activities are prohibited. However, in the above language, Congress acknowledged that there are times when exceptions are allowed to meet the minimum required administration of the area as wilderness.
How to Use This Guide
The Minimum Requirement Decision Guide displays a two-step process to assist in making the right decision for wilderness. First, the administrator must decide if a problem or issue in the wilderness unit needs administrative action, and then, and only then, the administrator must decide what tool/action/method, available from a range of identified alternatives, would minimize negative impacts on wilderness character and values. This guide includes templates for documenting both steps of the decision-making process, instructions for completing each step, and a cover sheet for signatures. The Minimum Requirement Decision Guide and future revised editions of the guide can be found on the Arthur Carhart National Wilderness Training Center page at www.wilderness.net.

STEP 1 – DETERMINING THE MINIMUM REQUIREMENT

Is Administrative Action Needed?
What is the problem/issue that may require administrative action? Do not include methods or tools here. This sheet only refers to the issue or problem, not proposed action/project, or tools to be used. Include references from other legislation, policy, or plans, decisions, analyses, and how this issue is addressed in

Briefly describe the issue/problem:

At least 1,000 non-native axis deer (*Axis axis*) and fallow deer (*Dama dama*) inhabit wilderness, natural and pastoral areas of Point Reyes National Seashore. Both species were introduced to the area, before establishment of the Seashore, by a local landowner who purchased individuals from the San Francisco Zoo in the 1940s and 1950s for hunting purposes. The deer now inhabit the entire park and threaten to establish viable populations outside park borders. There is a need to address potential adverse impacts to native species from non-native deer, to maintain native ecosystems, to prevent spread of non-native deer outside NPS boundaries and to eliminate adverse impacts of non-native deer to agricultural lessees.

The following questions assist in analyzing whether the issue needs to be resolved in wilderness. Do not consider what tools are to be used here. Please circle **Yes** or **No**, and explain your reasoning:

1. Is this an emergency? **Yes** $\boxed{\textbf{No}}$ If yes, follow established procedures for Search and rescue (SAR), fire or other plans/policies. If no, please continue.

2. Is this problem/issue subject to valid existing rights, such as access to valid mining claim, state lands, etc? **Yes** $\boxed{\textbf{No}}$
If no, continue with **Sheet 1**.
If yes, briefly explain here and then proceed to **Sheet 3**

3. Can the problem/issue be addressed by administrative actions outside a wilderness area? (For example, the administrative actions could be an information program at the visitor center or trailhead instead of a physical action in the wilderness, etc) **Yes** $\boxed{\textbf{No}}$
If yes, conduct actions outside wilderness. If no, continue with **Sheet 2**.

4. Is there a special provision in legislation (the 1964 Wilderness Act or subsequent laws), that allows this project or activity? (For example, maintenance of dams or water storage facilities, access to private inholdings, etc.) **Yes** $\boxed{\textbf{No}}$ **If yes, Go to SHEET 3; if no, Go To SHEET 2.**

Is Administrative Action Needed? (Continued)
If the issue/problem is not resolved, or action is not taken, will the natural processes of the wilderness be adversely affected?

$\boxed{\text{Yes}}$ No Why/How?

Current population indices and recent range expansion of non-native deer suggest that at least one species (fallow deer) will continue to increase in number and range throughout wilderness areas of the Seashore. This invasive species will increasingly interfere with natural processes.

If the issue/problem goes unresolved, or action is not taken, will the values of solitude or primitive and unconfined type of recreation be threatened?

Yes $\boxed{\text{No}}$ Why/How?

The presence of non-native deer does not impact the values of solitude or quality of primitive and unconfined recreation.

3. If the issue/problem goes unresolved or action is not taken will evidence of human manipulation, permanent improvements, or human habitation be substantially noticeable ?

$\boxed{\text{Yes}}$ No Why/How?

Exotic deer in the wilderness ecosystem are evidence of human caused non-native species introduction. Because of their numbers and range, non-native deer are substantially noticeable.

4. Does addressing the issue/problem or taking action protect the wilderness as a whole as opposed to a single resource?

$\boxed{\text{Yes}}$ No Why/How?

Non-native deer likely impact the native ecosystem they inhabit on several levels, by consuming native vegetation, competing with native herbivores and causing local impacts to soils and water resources.

5. Does addressing this issue/problem or taking action contribute to protection of an enduring resource of wilderness for future generations?

$\boxed{\text{Yes}}$ No Why/How?

Addressing the problem of non-native deer substantially contributes to the restoration and protection of native wilderness ecosystems for future generations.

6. Is this an issue for reasons other than convenience or cost of administration?

$\boxed{\text{Yes}}$ No Why/How?

If administrative action is warranted, then proceed to Sheet 3 to determine the minimum tool or method for resolving the problem.

Identify and describe a range of alternatives including those that utilize traditional tools and non-motorized and mechanized means as well as other methods.

Alternative A: No Action

This alternative would perpetuate non-native deer management practices since 1995, when ranger culling was discontinued. No non-native deer control actions would be undertaken. Monitoring activities, as outlined in Chapter 2 (Actions Common to All Alternatives) would continue in perpetuity.

Circle yes or no:
Does this alternative involve:

use of temporary road?	Yes	No
use of motor vehicles?	Yes	No
use of motorized equipment?	Yes	No
use of motorboats?	Yes	No
landing of airplanes?	Yes	No
landing of helicopters?	Yes	No
use of mechanical transport?	Yes	No
creating a structure or installation?	Yes	No
Other impacts to wilderness character?	Yes	No

Describe the biophysical effects/benefits of this alternative:

In order to ensure protection of native species and ecosystems, continued monitoring would be an integral part of this action alternative. Helicopter use to monitor non-native deer populations and range may be required.

Describe the social/recreation effects/benefits:
None.

Describe societal/political effects/benefits:
None.
Describe health and safety concerns/benefits:
Use of helicopters to monitor non-native deer populations and range may result in some risk to NPS staff and visitors from aviation accidents.

Describe economic and timing considerations/benefits:
None.

Describe heritage resource considerations/benefits:
None.

Identify and describe a range of alternatives including those that utilize traditional tools and non-motorized and mechanized means as well as other methods.

Alternative B: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal

Non-native deer populations would be controlled initially to a level of 350 for each species (700 total axis and fallow deer). Control of each non-native deer species to 350 animals would be accomplished with lethal removal by NPS staff or contractors specifically trained in wildlife sharpshooting. Efforts would be made to reach target levels in 15 years, to ensure continued presence of both species in the Seashore, and to reduce risks of range expansion beyond Seashore boundaries. Because the goal of this alternative would be to control axis and fallow deer at a specified level and not to eradicate them from PRNS, annual culling would continue indefinitely and total numbers of deer removed is incalculable. Where axis and fallow deer carcasses can be moved, they would be donated to charitable organizations as food for the needy or to assist in endangered species recovery programs. In cases where carcasses cannot be accessed, they would be left in place to recycle nutrients into the ecosystem. Monitoring activities would continue for the life of the Plan.

Circle yes or no:
Does this alternative involve:

use of temporary road?	Yes	$\boxed{\text{No}}$
use of motor vehicles?	$\boxed{\text{Yes}}$	No
use of motorized equipment?	Yes	$\boxed{\text{No}}$
use of motorboats?	Yes	$\boxed{\text{No}}$
landing of airplanes?	Yes	$\boxed{\text{No}}$
landing of helicopters?	$\boxed{\text{Yes}}$	No
use of mechanical transport?	Yes	$\boxed{\text{No}}$
creating a structure or installation?	Yes	$\boxed{\text{No}}$
Other impacts to wilderness character?	Yes	$\boxed{\text{No}}$

Describe the biophysical effects/benefits of this alternative:

Long-term, lower non-native deer numbers would result in beneficial impacts to hydrologic processes, soils, vegetation, native wildlife and special status species.

Describe the social/recreation effects/benefits:

Short-term, public access to some areas could be restricted during lethal removals.

Describe societal/political effects/benefits:

None.

Describe health and safety concerns/benefits:

Use of helicopters and firearms may result in some risk to NPS staff and visitors.

Describe economic and timing considerations/benefits:

Reduction of non-native deer numbers before populations and range increase further will reduce the overall cost of the control program.

Describe heritage resource considerations/benefits:
None

Identify and describe a range of alternatives including those that utilize traditional tools and non-motorized and mechanized means as well as other methods.

Alternative C: Control of Non-Native Deer at Pre-Determined Levels by Agency Removal and Fertility control (Sterilants or Yearly Contraception)

Non-native deer populations would be controlled initially to a level of 350 for each species (700 total axis and fallow deer) using both lethal removal and fertility control. Efforts would be made to reach target levels in 15 years, to ensure continued presence of both species in the Seashore, and to reduce risks of range expansion beyond Seashore boundaries. The contraceptive program would incorporate the latest contraceptive technologies to safely prevent reproduction, for as long as possible, and with minimal treatments per animal. Because the goal of this alternative would be to control axis and fallow deer at a specified level and not to eradicate them from PRNS, annual culling and fertility control would continue indefinitely and total numbers of deer removed and treated with contraceptives is incalculable. Monitoring activities would continue in perpetuity.

Circle yes or no:
Does this alternative involve:

use of temporary road?	Yes	$\boxed{\text{No}}$
use of motor vehicles?	$\boxed{\text{Yes}}$	No
use of motorized equipment?	Yes	$\boxed{\text{No}}$
use of motorboats?	Yes	$\boxed{\text{No}}$
landing of airplanes?	Yes	$\boxed{\text{No}}$
landing of helicopters?	$\boxed{\text{Yes}}$	No
use of mechanical transport?	Yes	$\boxed{\text{No}}$
creating a structure or installation?	Yes	$\boxed{\text{No}}$
Other impacts to wilderness character?	Yes	$\boxed{\text{No}}$

Describe the biophysical effects/benefits of this alternative:

Long-term, lower non-native deer numbers would result in beneficial impacts to hydrologic processes, soils, vegetation, native wildlife and special status species.

Describe the social/recreation effects/benefits:

Short-term, public access to some areas could be restricted during lethal removals and contraception.

Describe societal/political effects/benefits:

None.

Describe health and safety concerns/benefits:

Use of helicopters and firearms may result in some risk to NPS staff and visitors.

Describe economic and timing considerations/benefits:

Reduction of non-native deer numbers before populations and range increase further will reduce the overall cost of the control program.

Describe heritage resource considerations/benefits:

None

Identify and describe a range of alternatives including those that utilize traditional tools and non-motorized and mechanized means as well as other methods.

Alternative D : Removal of All Non-Native Deer from Point Reyes National Seashore (PRNS) and PRNS-Administered Lands of Golden Gate National Recreation Area (GGNRA) by Agency Removal

In Alternative D, all axis and fallow deer inhabiting the Seashore and the GGNRA lands administered by the Seashore would be eradicated by 2021 through lethal removal by NPS staff or contractors specifically trained in wildlife sharpshooting. Where deer carcasses can be moved, they would be donated to charitable organizations as food for the needy or to endangered species recovery programs. In cases where carcasses cannot be accessed, they would be left in place to recycle nutrients into the ecosystem. Monitoring activities would continue until all non-native deer are eradicated, by 2021.

Circle yes or no:
Does this alternative involve:

use of temporary road?	Yes	$\boxed{\text{No}}$
use of motor vehicles?	$\boxed{\text{Yes}}$	No
use of motorized equipment?	Yes	$\boxed{\text{No}}$
use of motorboats?	Yes	$\boxed{\text{No}}$
landing of airplanes?	Yes	$\boxed{\text{No}}$
landing of helicopters?	$\boxed{\text{Yes}}$	No
use of mechanical transport?	Yes	$\boxed{\text{No}}$
creating a structure or installation?	Yes	$\boxed{\text{No}}$
Other impacts to wilderness character?	Yes	$\boxed{\text{No}}$

Describe the biophysical effects/benefits of this alternative:

Long-term, eradication of non-native deer would result in beneficial impacts to hydrologic processes, soils, vegetation, native wildlife and special status species.

Describe the social/recreation effects/benefits:

Short-term, public access to some areas could be restricted during lethal removals.

Describe societal/political effects/benefits:

None.

Describe health and safety concerns/benefits:

Use of helicopters and firearms may result in some risk to NPS staff and visitors.

Describe economic and timing considerations/benefits:

Reduction of non-native deer numbers before populations and range increase further will reduce the overall cost of eradication.

Describe heritage resource considerations/benefits:

None.

What is the method or tool that will allow the issue/problem to be resolved or an action to be implemented with a minimum of impacts to the wilderness?

The Selected alternative is: **Alternative E.**

Identify and describe a range of alternatives including those that utilize traditional tools and non-motorized and mechanized means as well as other methods.

Alternative E (Proposed Action): Removal of All Non-Native Deer from Point Reyes National Seashore (PRNS) and PRNS-Administered Lands of Golden Gate National Recreation Area (GGNRA) by a Combination of Agency Removal and Fertility control (Sterilants or Yearly Contraception)

In Alternative E, all axis and fallow deer inhabiting the Seashore and the GGNRA lands administered by the Seashore would be eradicated by 2021 through lethal removal and fertility control. Culling would be conducted by NPS staff or contractors specifically trained in wildlife sharpshooting. The contraceptive program would incorporate the latest experimental contraceptive technologies to safely prevent reproduction, for as long as possible, and with minimal treatments per animal. Where deer carcasses can be moved, they would be donated to charitable organizations as food for the needy or for endangered species recovery programs. In cases where carcasses cannot be accessed, they would be left in place to recycle nutrients into the ecosystem. Monitoring activities would continue until all non-native deer are eradicated, by 2021.

Circle yes or no:
Does this alternative involve:

use of temporary road?	Yes	$\boxed{\text{No}}$
use of motor vehicles?	$\boxed{\text{Yes}}$	No
use of motorized equipment?	Yes	$\boxed{\text{No}}$
use of motorboats?	Yes	$\boxed{\text{No}}$
landing of airplanes?	Yes	$\boxed{\text{No}}$
landing of helicopters?	$\boxed{\text{Yes}}$	No
use of mechanical transport?	Yes	$\boxed{\text{No}}$
creating a structure or installation?	Yes	$\boxed{\text{No}}$
Other impacts to wilderness character?	Yes	$\boxed{\text{No}}$

Describe the biophysical effects/benefits of this alternative:

Long-term, removal of all non-native deer would result in beneficial impacts to hydrologic processes, soils, vegetation, native wildlife and special status species.

Describe the social/recreation effects/benefits:

Short-term, public access to some areas could be restricted during lethal removals or contraception operations.

Describe societal/political effects/benefits:

None.

Describe health and safety concerns/benefits:

Use of helicopters and firearms may result in some risk to NPS staff and visitors.

Describe economic and timing considerations/benefits:

Reduction of non-native deer numbers before populations and range increase further will reduce the overall cost of eradication.

Describe heritage resource considerations/benefits:
None

STEP 2: DETERMINING THE MINIMUM TOOL

Sheet 4: Selection of the Minimum Tool Alternative

Attach all alternative sheets to this summary page.

Describe the rationale for selecting this alternative

Eradication of non-native deer will be an important step in the restoration of native ecosystems in Seashore wilderness areas and will assist in protection of vegetation, native herbivores, special status species, hydrological and soil resources for the future. Use of long-lasting fertility control, should it prove effective, will reduce the number of deer that need to be culled, consequently reducing the amount of vehicular and helicopter use in the wilderness.

Describe the specific operating requirements for the action. Include information on timing, locations, type of actions, etc. (Use this space or attach a separate sheet)

This alternative requires the use of helicopters for monitoring and deer removal activities. Although it is unlikely that such use would result in helicopter landings in wilderness, emergency landings are always possible. Alternative E also requires the use of vehicles in wilderness to transport NPS sharpshooters and to remove carcasses for donation to charity.

What are the maintenance requirements? This alternative requires maintaining current roads and trails in wilderness.

What standards and designs will apply? **Not applicable.**

Develop and describe any mitigation measures that apply. Aerial operations will not take place during high visitation months or during weekends. Use of vehicles will be restricted to currently permitted roads. Inaccessible carcasses will not be retrieved and will be left to recycle nutrients into the ecosystem.

What will be provided for monitoring and feedback to strengthen future effects and preventative actions to be taken to help in future efforts? **Deer population monitoring will inform mangers on the success of implementation of alternative E. Experts on capture and deer control will be consulted in the first 3 years of the plan to ensure safety and efficacy of the protocols.**

Appendix B: Non-Native Deer Population Model (Barrett)

A. Deer Harvest Models:

POPMODFD (for fallow deer) and POPMODAD (for axis deer), version 12-13-2000, are spreadsheet models developed by Reginald Barrett (Gogan et al. 2001). The models' primary use is to determine the effects of any proposed harvest schemes on axis and fallow deer populations. The mathematical formulas are based on published literature and expert opinion. They assume that survival rates and recruitment of young into the population are all density dependent. In other words, as deer populations increase towards carrying capacity (K), survival of various age groups decreases, as do the birth rate and survival of fawns. The patterns of density dependence were derived from field observations, necropsy data and the published literature on both species. Simulation of future population scenarios requires input from the user of estimates for starting population, carrying capacity and lethal removals (if any).

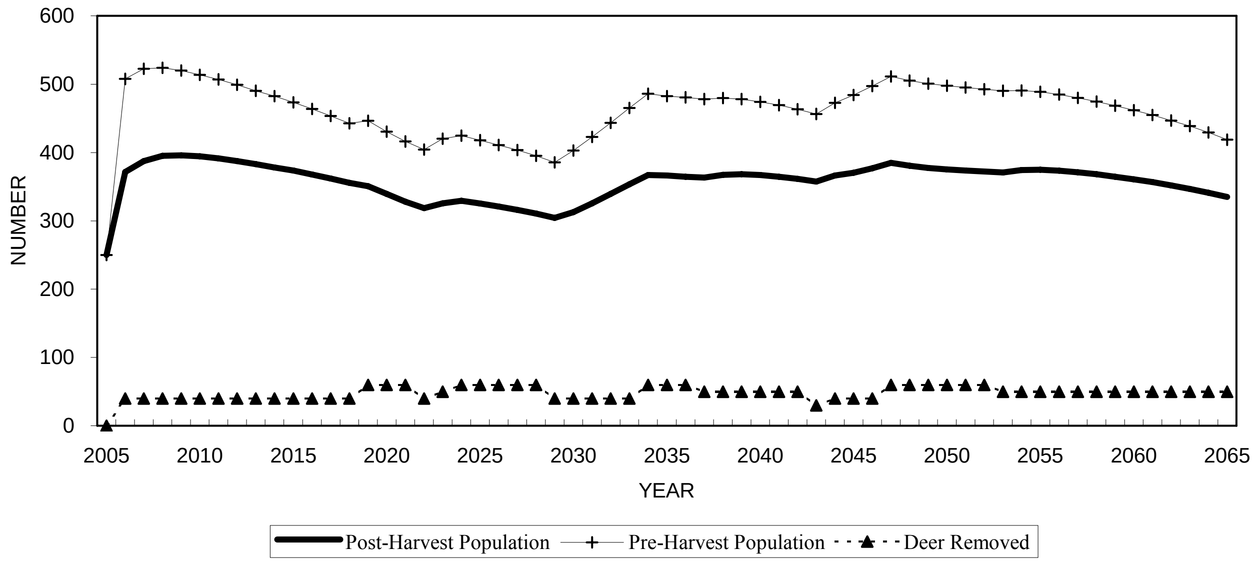
By using past numbers of animals culled as well as populations estimates from the 1970s, Gogan et al. (2001) derived values for carrying capacity of 455 and 775 for axis and fallow deer respectively. These are the population sizes at which population growth essentially stops. It should be noted that in the case of fallow deer, PRNS estimates of the current numbers (N = 859, 90% Confidence Interval = 547 - 1170) slightly exceed the Gogan et al. estimates for carrying capacity (PRNS unpublished data (f)). Wildlife population numbers should always be interpreted as estimates within a confidence interval. As in all empirical models based on such estimates, the Barrett models are best used to detect future trends rather than exact numbers.

Using the Barrett models, we can investigate the effects of culling on either species. If we input current estimates for axis and fallow deer numbers and use the above values for carrying capacity, the following scenarios result.

1. Alternative B - Remove 25-50 axis deer yearly, once the population surpasses 350:

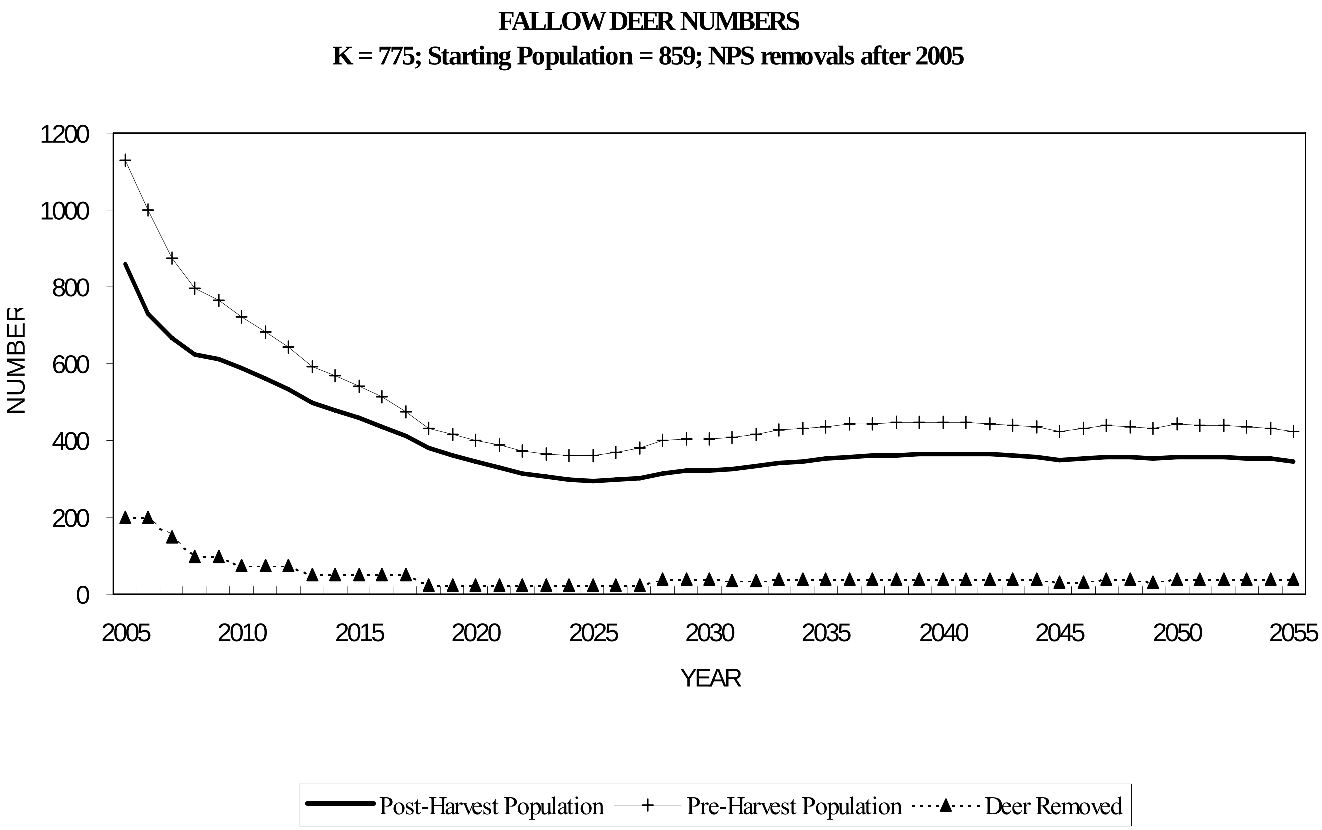
AXIS DEER NUMBERS

K = 445; Starting Population = 250; NPS removals after population reaches 350 (illustrated here as occurring in 2006)



Approximate number of axis deer removed by 2021 = 650
Approximate number of axis deer removed by 2050 = 2,200

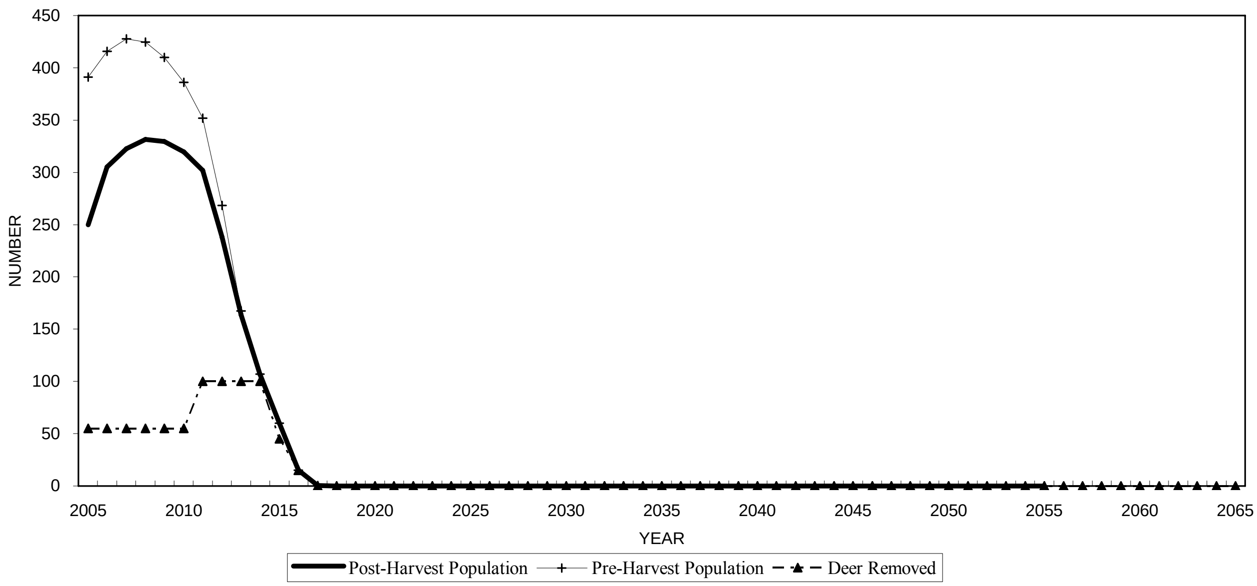
2. Alternative B – Remove 100-200 fallow does yearly until the population reaches 350, and remove 50-75 deer yearly thereafter:



Approximate number of fallow deer removed by 2021 = 2,400
Approximate number of fallow deer removed by 2050 = 5,500

3. Alternative D – Remove 50-100 axis deer yearly until eradication:

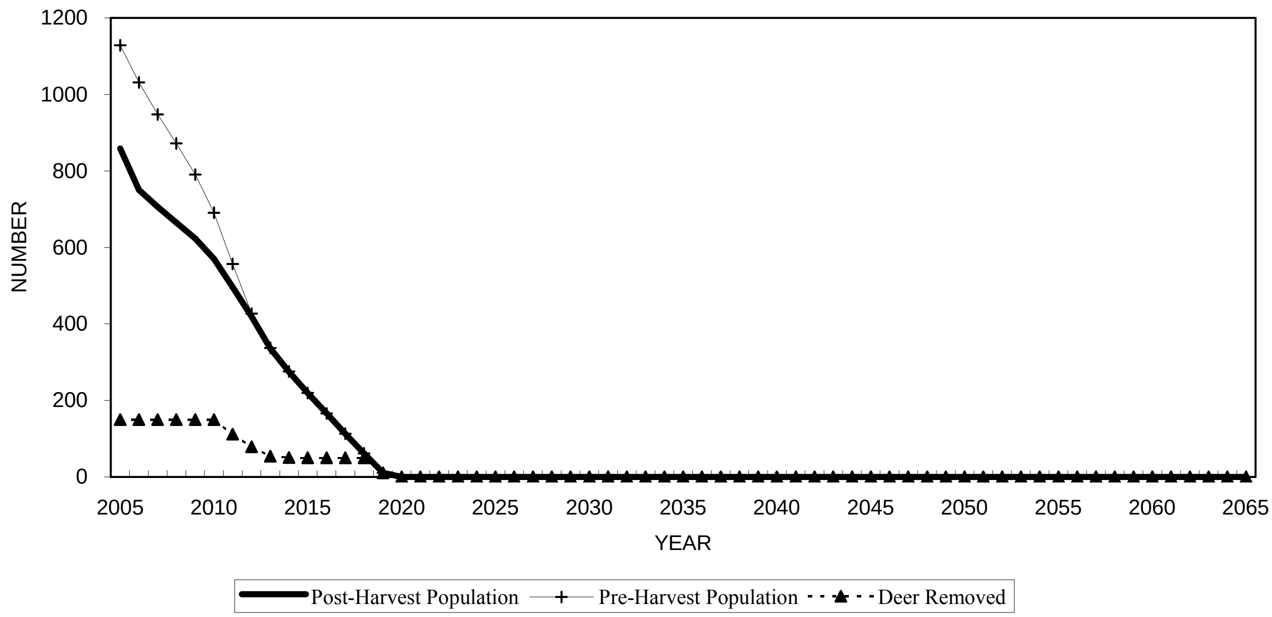
AXIS DEER NUMBERS
K= 445; Starting Population = 250; NPS removals after 2005



Approximate number of axis deer removed until eradication (in approximately 2017) = 800

4. Alternative D – Remove 150-200 fallow deer yearly until eradication:

FALLOW DEER NUMBERS
K=775; Starting Population = 859; NPS removals after 2005



Approximate number of fallow deer removed until eradication (in approximately 2021) = 1,400

Yearly Contraception Model

In 2002, Barrett also incorporated fertility control, without lethal removal, into the above fallow deer model (POPMODFD) to simulate the use of yearly contraception as the sole method of population control for fallow deer (Barrett 2002 unpublished data). The model assumes use of a contraceptive agent that is 100% effective in preventing pregnancy for up to 12 months, and that all treated animals can be marked to avoid double treatment. The model uses the above values for fallow deer carrying capacity (K = 775) and starting population size (N = 859).

Barrett found that yearly contraception of at least 80% of does was required to reduce the population to 350 within 25 years. This represents a treatment group size of over 300 animals yearly for the first 6 years. Barrett also found that, in the absence of lethal removal, 99% of reproducing females would require treatment with a 100% effective yearly contraceptive in order to eradicate all fallow deer in 20 years. This would constitute a treatment group size of up to 550 animals per year during the first 5 years of the program.

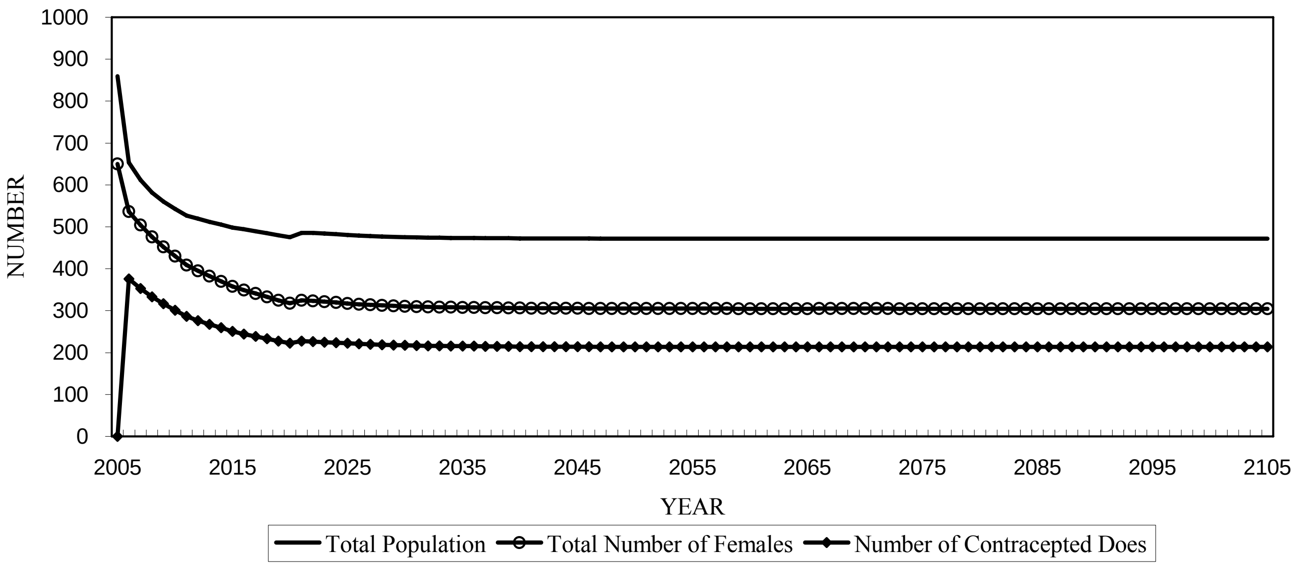
The following projections simulate treatment of various proportions of the fallow doe population with a yearly contraceptive "vaccine" similar to that which has been used in tule elk at Point Reyes National Seashore. For a discussion of current wildlife contraceptive technology, refer to the discussion of contraceptives under Alternative C. It should be noted that the currently available wildlife contraceptive vaccine (porcine Zona Pellucida) requires a second booster injection during the first year of administration to be effective in preventing pregnancy in tule elk and other cervids (Kirkpatrick et al. 1996b; Shideler 2000). A second treatment is not included in the following projections; therefore, projected numbers of treatments should be considered minimum figures.

The action alternatives that include the use of yearly contraceptives to either control the fallow deer population at a pre-determined level or to eradicate the fallow deer from the Seashore are further discussed in the section *Alternatives and Actions Considered but Rejected*. Because of the numbers of animals that would require capture, handling and treatment, these alternatives were dismissed from consideration due to infeasibility.

1. Contraception of 70% of fallow does yearly, beginning in 2006, with no lethal removals:

In this scenario, with 200-400 does treated every year, the total population never drops below 470 animals.

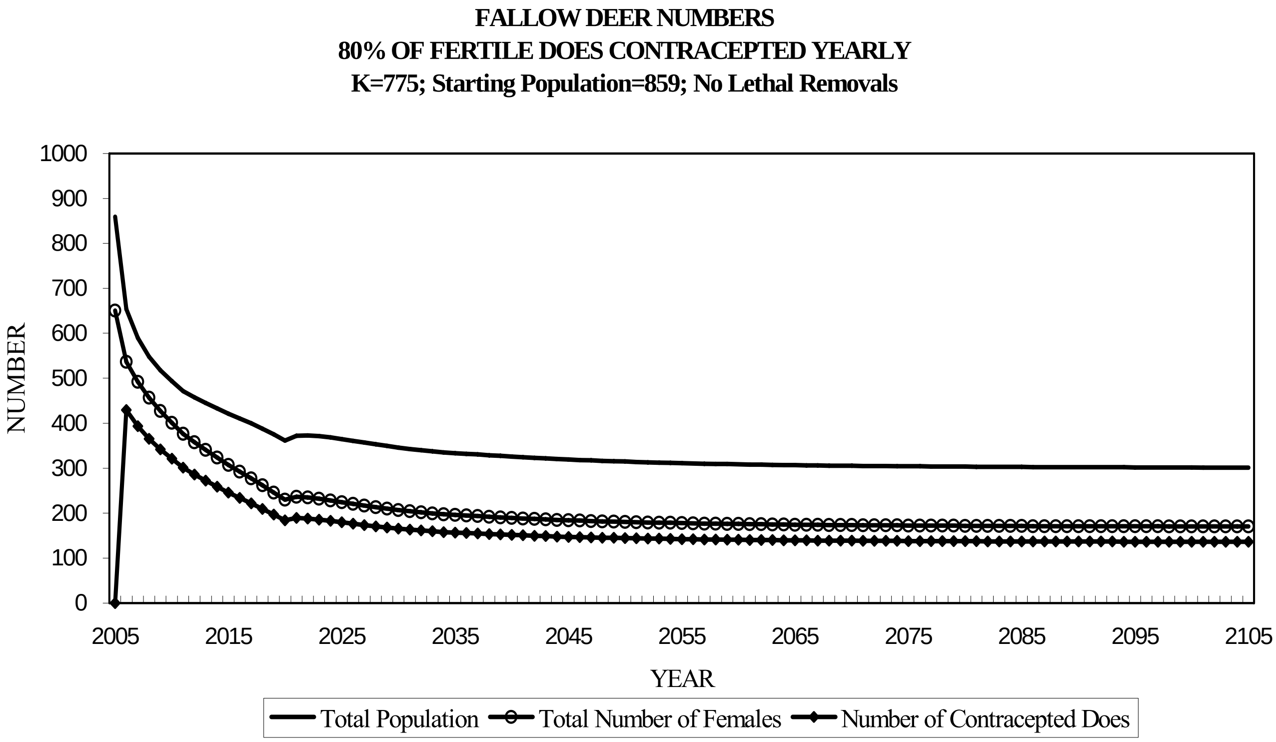
FALLOW DEER NUMBERS
70% OF FERTILE DOES CONTRACEPTED YEARLY
K=775; Starting Population=859; No Lethal Removals



Approximate number of treatments by 2021 = 4,200
Approximate number of treatments by 2050 = 11,000

2. Contraception of 80% of fallow does yearly, beginning in 2006, with no lethal removals (Alternative and Action Considered but Rejected) :

In this scenario, the population reaches 350 in 2030, with up to 450 females treated yearly. Here, total numbers treated are less than in the 70% treatment scenario because the number of fertile females and the total population are both reduced more rapidly.

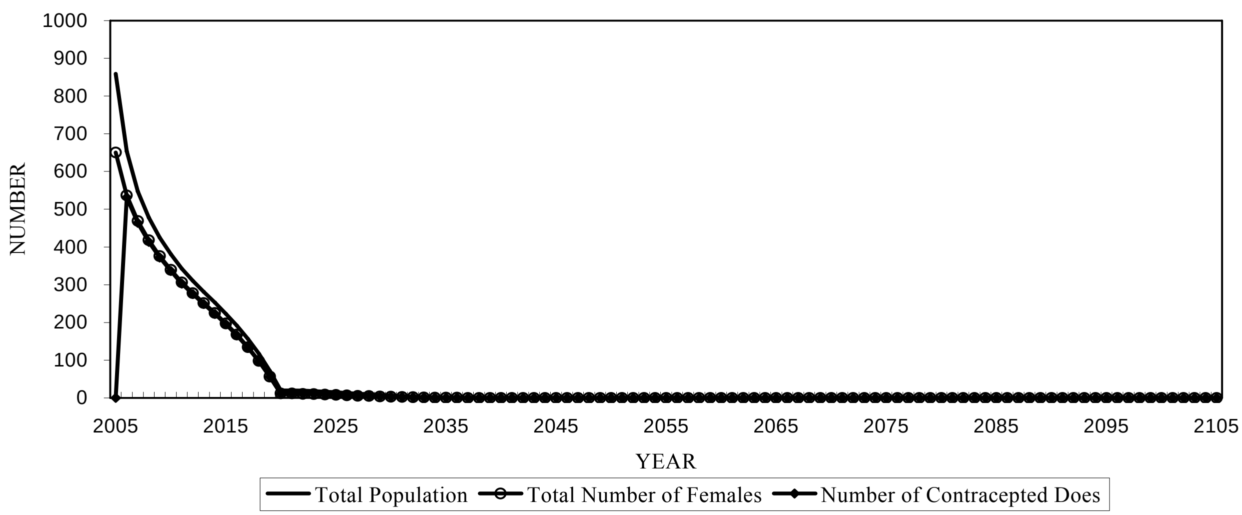


Approximate number of treatments by 2021 = 4,300
Approximate number of treatments by 2050 = 9,100

3. Contraception of 99% of fallow does yearly, beginning in 2006, with no lethal removals (Alternative and Action Considered but Rejected):

In this scenario, up to 500 does are treated yearly during the first 10 years of the program. The population decreases rapidly but is not eradicated until the last doe dies of old age in approximately 2035. Again, total numbers treated are less than in the 70% or 80% treatment scenarios because the number of fertile females and total population are both reduced more rapidly. Most of the population effect of the treatment takes place in the first few years of the program when over 400 does per year are treated.

FALLOW DEER NUMBERS
99% OF FERTILE DOES CONTRACEPTED YEARLY
K=775; Starting Population=859; No Lethal Removals



Approximate number of treatments by 2021 = 3,800
Approximate number of treatments by eradication (approximately 2035) = 3,900

Appendix C: Monitoring and Management Plan for Action Alternatives B, C, D and E

Alternatives B through E contain actions to accomplish the following objectives:

- To correct past and ongoing disturbances to Seashore ecosystems from non-native deer and thereby to contribute substantially to the restoration of naturally functioning native ecosystems.
- To minimize long-term impacts, in terms of reduced staff time and resources, to resource protection programs at the Seashore, incurred by continued monitoring and management of non-native deer.
- To prevent spread of populations of both species of non-native deer beyond Seashore and GGNRA boundaries.
- To reduce impacts of non-native deer through direct consumption of forage, transmission of disease to livestock, and damage to fencing to agricultural permittees within pastoral areas.

The purpose of this monitoring plan is to describe how NPS will collect the information required to design a specific implementation plan for the Preferred Alternative and to modify this plan in future years as a way of ensuring that the above objectives are met.

Successful management of natural systems is a challenging and complicated undertaking. The Department of the Interior requires that its agencies "use adaptive management to fully comply" with the Council on Environmental Quality's guidance that requires "a monitoring and enforcement program to be adopted . . . where applicable, for any mitigation" (516 DM 1.3 D(7); 40 CFR 1505.2). Adaptive management is based on the assumption that current resources and scientific knowledge are limited. Nevertheless, an adaptive management approach attempts to apply available resources and knowledge and adjusts management techniques as new information is revealed. The principle of adaptive management requires management decisions and policies to be viewed as hypotheses subject to change.

Adaptive management incorporates scientific experimental methods in the management process while remaining flexible to adjust to changes in the natural world, as well as policies that govern it. The goal is to give policy makers a better framework for applying scientific principles to complex environmental decisions.

Through the Environmental Impact Analysis process, NPS has determined that accomplishing the above objectives can only be achieved through reduction of non-native deer numbers to a certain level (Alternatives B and C) or complete removal of all non-native deer from the Seashore (Alternatives D and E). In all four of the Action Alternatives (B, C, D, and E), there are two specific techniques used for control of non-native deer numbers, fertility control (long-duration contraception) and lethal removal. What follows is a description of the parameters that will guide implementation of the Preferred Alternative, how the success of long-lasting contraception or lethal removal will be ascertained and what conditions would indicate a change in these two techniques.

Implementation of the Preferred Action Alternative (E)

In Alternative E, all axis and fallow deer inhabiting the Seashore and the GGNRA lands administered by the Seashore would be removed by 2021. Management techniques would include lethal removal and fertility control (long-lasting contraception or sterilization of deer). Both actions would continue until both axis and fallow deer have been extirpated. Because of their current large populations (approximately 250 axis deer and approximately 860 fallow deer), it is expected that total removal of both species would require a minimum of 13 years, regardless of the technique(s) used. Before initiation of management, experts from the fields of wildlife contraception and deer control would be consulted to refine the important details of implementation. An example of such a detail would be seasonality of fertility control and culling. Another example would be capture sites for experimentally treated deer or focus sites for culling. These implementation details would be subject to review during the plan's duration and alteration based on the data collected on management effectiveness (see Modification of Plan Actions section below). These details do not alter the basic approach of the Preferred Alternative or the environmental impacts as described in this environmental impact statement, but will help the Seashore in maximizing efficiency and achieving the objectives to the greatest possible degree. Monitoring during program implementation would be done to assess success of the program and to guide adjustments in the management techniques used (see Measuring Success section below).

Measuring Success

On a regular basis, the Seashore Resource Management staff and NPS subject matter experts will evaluate the progression of the non-native deer management program towards the four objectives of the management plan. Frequency of reevaluation will depend on the resource being monitored and rates of change (recovery) of this resource. Specifics of this self-evaluation are detailed below:

Objective 1 – Correcting disturbance caused by non-native deer and contributing to ecosystem restoration

As non-native deer numbers decrease, their impacts to native ecosystems are also expected to decrease. This improvement in ecosystem characteristics and processes is expected to manifest itself as any or all of the following:

- In fallow deer lekking areas - reduced bare soil, reduced damage to understory vegetation, reduced trampling and trailing, reduced girdling of trees, reduced incursion of exotic plants
- In fallow and axis deer year-round congregation areas – reduced bare soil, reduced damage to understory vegetation, reduced trampling and trailing, reduced girdling of trees, reduced incursion of exotic plants
- Improved habitat in riparian areas within non-native deer ranges for anadromous fish, amphibians and riparian-dependent birds
- Reduced exposure of native cervids to diseases carried by non-native deer, namely paratuberculosis (Johne's disease) and exotic lice
- Reduced competition between native and non-native deer for limited forage, particularly during times of low forage availability such as during summer and droughts
- Reduced behavioral competition between native and non-native deer

Any or all of the following methods will be used to assess signs of ecosystem restoration mentioned above:

- Monitoring of native and non-native deer numbers through park-wide aerial and/or ground censusing, indirect indices (pellet group or spotlight counts) or area sampling, performed at intervals of 1-3 years. Any use of aircraft to monitor deer would comply with Office of Aircraft Safety regulations and policies for all NPS aerial operations (Director's Order 60).
- Monitoring of native and non-native deer population growth rates through composition counts, with or without multi-year surveillance of marked animals for determination of survival and fecundity rates.
- Monitoring of the diets of native and non-native deer to assess dietary overlap given the new ranges occupied by exotic deer and new deer herd sizes since the previous dietary studies of 1973 and 2000 (Elliott 1983; Fallon-McKnight 2006). Particular attention would be given to assessing the importance of threatened and endangered plant species in the diets of all deer species as well as dietary overlap between non-native deer, native black-tailed deer and native tule elk, re-introduced to Tomales Point in 1978 and the Limantour Wilderness Area in 1999.

- Surveillance for evidence of deer overuse in natural or wilderness areas in which non-native deer are found in high densities. This could include measurements of bare soil and vegetative cover as well as erection of deer-proof exclosures, as experimental controls, in wilderness areas.
- Monitoring of disease in all non-native deer found in high densities within pastoral areas, and in direct contact with livestock within Seashore boundaries. Disease testing could entail collection and complete necropsy of a sample of any deer species for which the two above requirements were satisfied, along with laboratory analysis of appropriate biological samples.

Objective 2 – Minimize long-term impacts, in terms of reduced staff time and resources, to resource protection programs at the Seashore, incurred by continued monitoring and management of non-native deer

Active management of non-native deer, through fertility control and lethal removal, is expected to initially result in increased expenditures of NPS funds and staff time. In the early years of the management program, the capture of large number of deer to administer experimental contraception and the lethal removal of a large number of deer will cause impacts to park operations that should decrease with decreasing non-native deer numbers. However, the wildlife management literature demonstrates that a few, wary deer are often more expensive and time-consuming to control than many, naïve deer. This increased wariness and reduced visibility of the non-native deer in the later years of the 15-year program will result in disproportionate management costs per deer, although since there will be many fewer deer, the overall costs per year are expected to drop. When all non-native deer have been removed (predicted to be in 2021), costs associated with monitoring or managing them will disappear. Progression towards this goal will be measured, during the life of the plan, by monitoring of the costs of the management program including: staff time, training, administrative, legal, and public relations costs and the costs of monitoring as described above.

Objective 3 – To prevent spread of populations of both species of non-native deer beyond Seashore and GGNRA boundaries

NPS believes that the most effective way to accomplish Objective 3 is to reduce non-native deer numbers rapidly. Any deer control program involving lethal removal of animals with firearms has the potential to scatter deer herds and push deer out of the Seashore and into adjacent lands. Provisions described in Alternative B, C, D and E that specify removing animals from the edges of the Seashore before culling animals deeper within the park would mitigate such scattering, as would an initial larger scale removal. Assessing the program's success in achieving Objective 3 will involve monitoring of non-native deer range year-round with special emphasis on identifying changes in non-native deer range beyond Seashore boundaries or within the park as a reaction to management actions. Should exotic deer expand outside the park, the Seashore would provide assistance to California Department of Fish and Game to conduct monitoring programs outside its borders.

Objective 4 – To reduce impacts of non-native deer through direct consumption of forage, transmission of disease to livestock, and damage to fencing to agricultural permittees within pastoral areas.

It is expected that as non-native deer numbers decrease through NPS management, impacts to ranchers within the Seashore will also decrease. Success in achieving Objective 4 will be assessed through communication with ranchers and yearly field assessments by Seashore biologists and range ecologists.

Modification of Plan Actions

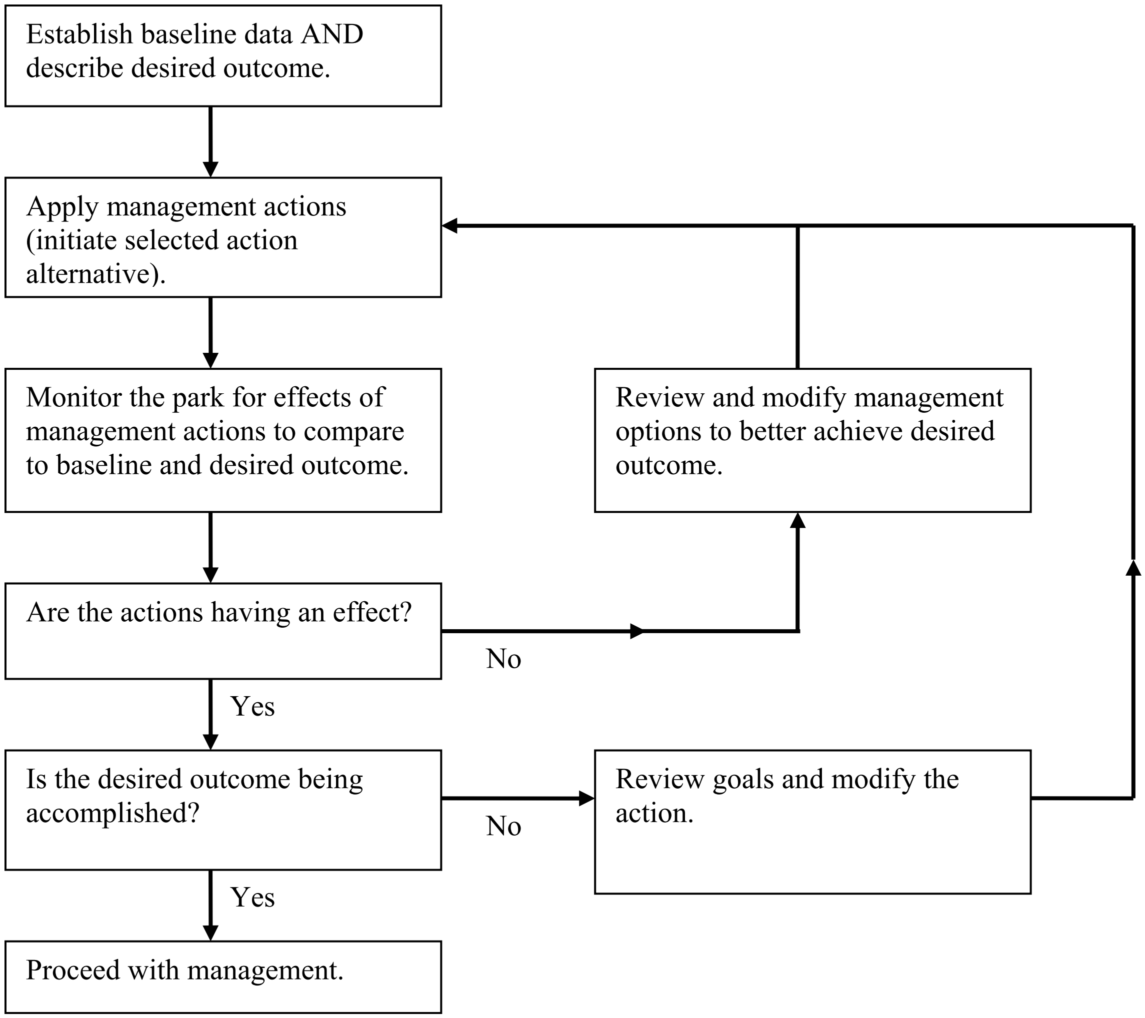
Achievement of the above objectives would warrant continued management as described in the Action Alternatives. However, as illustrated in Figure 1, if desired outcomes are not being achieved, when measured in the monitoring steps described above, a modification of action is warranted.

The two techniques proposed for managing deer numbers in Alternatives B, C, D, and E are experimental fertility control and lethal removal. The following data will be collected on these two techniques during the life of the plan:

- Experimental Fertility Control: In order to assess the efficacy of any experimental contraceptive treatment, treated deer would be permanently marked with radio collars and eartags and monitored for fecundity, mortality and any treatment side effects. In addition, necropsies on opportunistically recovered carcasses would provide data on safety and health effects of the agent.
- Lethal Removal: In order to assess the efficacy of lethal removals on non-native deer populations, data will be collected on numbers culled as well as sex, age class and culling locations. As mentioned above, monitoring of native and non-native deer numbers through park-wide aerial and/or ground censusing, indirect indices (pellet group or spotlight counts) or area sampling, would be performed at intervals of 1-3 years.

Should desired objectives not be met with the level of effort in contraception and lethal removal described in the alternatives, alterations in those levels will be made. Should deer numbers not decrease as predicted by population models (see Hobbs and Barrett models in the appendices), resource managers, along with experts in the field of wildlife contraception and deer management, could decide to increase either fertility control or culling. These decisions would take into account data on the effectiveness of these techniques. For example, should deer numbers fail to decrease along with adverse impacts to soils, vegetation and ranchers, and should 3 years of data on contraception indicate that treatment was only resulting in short-term inhibition of fawning, managers could decide to either try a more promising long-duration contraceptive or cull more animals per year. Conversely, should data indicate that the experimental contraceptive was 100% effective for 4 years or more, a decision could be made to treat more animals. It should be noted that the Preferred Alternative currently call for treating 25% of does. Based on past deer contraceptive programs and deer captures at PRNS, and for reasons of accessibility, Seashore managers believe that this level of treatment approaches the maximum feasible level. It is unlikely, unless deer contraceptive delivery methods change from injected to orally administered, that more than 25% of does could be treated. However, if this is not the case and the agent is both effective and more easily to deliver in the field, it may be used to treat additional deer. As noted in the EIS, the contraceptive program would be adaptively managed to incorporate the latest contraceptive technologies to safely prevent reproduction for as long as possible with minimal treatments per animal. As the technology of wildlife contraception changes, so too could the Seashore program.

Figure 1: An Illustration of the Adaptive Management Approach for the Action Alternatives



Appendix D: Final Report Point Reyes Fallow Deer Modeling

N. Thompson Hobbs
6/15/2003

Modeling Objective

I constructed a stage-based simulation model following Hobbs et al. (2000) to examine the effect of culling and fertility control on the abundance of fallow deer in Point Reyes National Seashore. Specific questions to be addressed by the model included:

a) How many animals must be culled or treated with contraceptives to eradicate the population?
b) Does fertility control offer a feasible alternative to culling as a way to eliminate fallow deer?
c) Can fertility control increase the efficiency of culling in an eradication campaign?
d) How does the duration of effect of contraception influence the number of animals that must be treated or culled to achieve eradication?

Model Structure

Overview

The model represents 2 sexes and 3 age stages, juveniles, yearlings and adults. The number of stages was chosen to represent important differences in survival and fertility and to facilitate comparison with field observations where no more than two ages can be identified. Census occurs in January and most mortality is assumed to occur between census and births (Figure 1). A birth pulse occurs during May, followed by breeding in late October. Thus, juveniles are 8 months old at the time of census. I assume that treatment with contraceptives occurs after births but before breeding. The model consists of linked difference equations and represents annual changes in abundance of animals in each stage (Figure 2) at a one year time step. Simple variations in model structure allow it to represent fertility control agents differing in duration of efficacy.

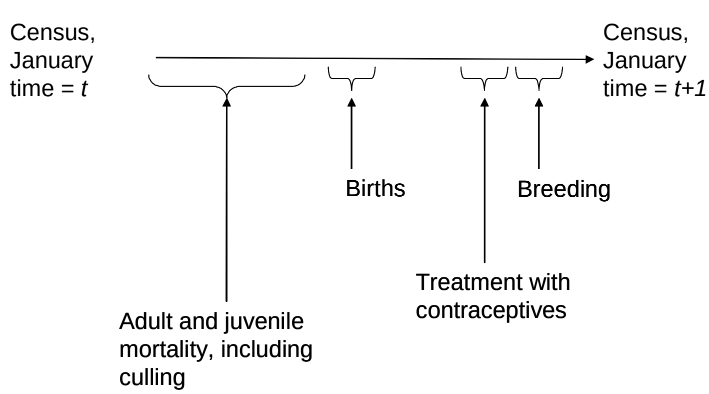


Figure 1. Assumed timing of events in fallow deer model.

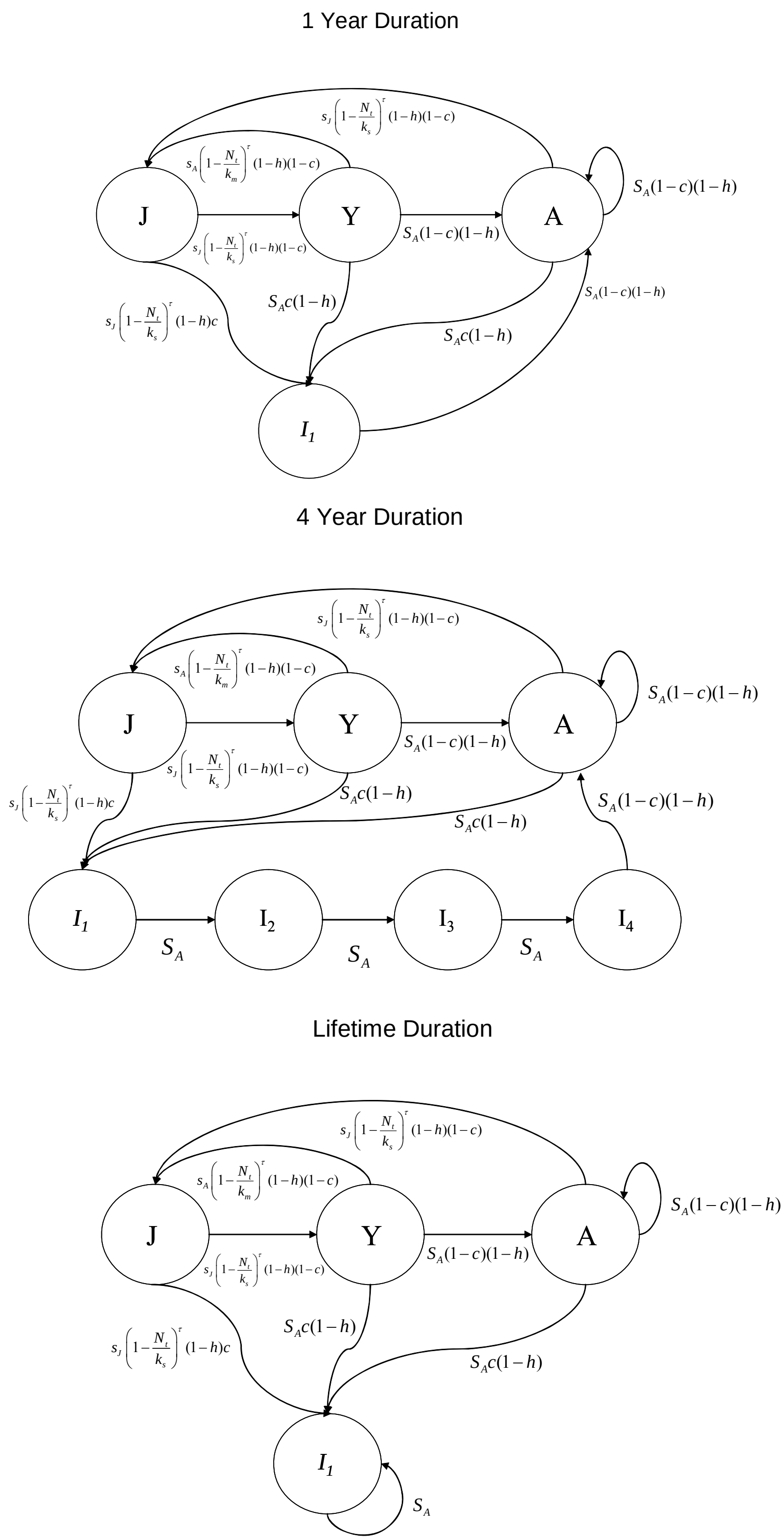


Figure 2. Structure of models used to represent effects of culling and fertility control on fallow deer populations in Point Reyes National Seashore. Duration refers to the length of time fertility control agents remain effective following treatment. See Table 1 for definitions of parameters. See text for definitions of state variables.

Model Parameters

Models include 7 parameters and two decision variables (Table 1). These are tabulated here to facilitate understanding the equations that follow. In a subsequent, section, I describe procedures for estimating parameter values.

Table 1. Values and Definitions for Parameters used in Fallow Deer Model.

Parameter	**Value**	**Definition**
m_A	.9	Maximum per capita rate of recruitment by adult females occurring when population size is close to 0. This recruitment rate specifies the number of offspring that survive to the first census produced per adult female alive at the birth pulse.
m_Y	.5	Maximum per capita rate of recruitment by yearling females occurring when population size is close to 0. This recruitment rate specifies the number of offspring that survive to the first census produced per yearling female alive at the birth pulse.
k_m	1500	The population size at which no offspring survive from birth to census.
r	.5	Sex ratio of offspring
s_J	.9	Maximum survival of juveniles. Juvenile survival is defined as the proportion of juveniles alive at census at time *t* that survive to become yearlings at time *t+1* and, thus, represents survival from age 8 to 20 months. The maximum value occurs when total population size is near 0.
s_A	.9	Adult survival rate, assumed to be constant.
k_s	3600	The population size where juvenile survival rate reaches a minimum value, assumed to be .10.
τ	1	Shape parameter controlling the abruptness of density dependence. As τ approaches 0, effects of density are not seen until large population sizes.
Decision Variables		
h	Specified by user	Culling rate, the number of animals that are culled during time t to t+1 divided by the number of animals that escape natural mortality during time t to t+1
c	Specified by user	Treatment rate, the number of animals treated with contraceptives during time t to t+1 divided by the number of animals that escape culling and natural mortality.

Model Formulation

The equations composing the 4 year duration fertility control model are outlined below in a form that isolates terms for the number of animals culled and treated with contraceptives. Formulating them this way leads to expressions that are not as compact as they could be, but which should be more easily understood than if I wrote equations in their simplest, most reduced form. Equations for the lifetime and single year duration models are variations of the 4 year case and will be described following the development of the 4 year model.

I first define a recruitment function, $f(Y_t, A_t, N_t)$ to estimate the number of fawns that are alive at their first census. This function represents fertility, the number of offspring born per female in the population, as well as survival during the animals first 7 months. I predict recruitment using,

$$f(Y_t, A_t, N_t) = s_A(Y_t m_Y + A_t m_A)\left(1 - \frac{N_t}{k_m}\right)^{\tau} \quad (1)$$

where t index time, Y_t is the number of yearling females at time t, A_t is the number adults at time t and N_t is total population size at time t. Adult survival is included in the recruitment function because adults must survive from census to births to contribute offspring at the next time step. To achieve a simple formulation, I assume that density affects the number of offspring produced by adults and yearlings in a similar fashion, but that adults produce more offspring than yearlings when density is low. The parameter τ controls the way that recruitment rate responds to density. When τ is 1, then the per capita recruitment rate declines linearly with increasing population size, which is the usual logistic assumption. When τ approaches 0, recruitment remains insensitive to changes in population numbers until high densities are reached (Figure 3) This parameter is included for sensitivity and uncertainty analysis because the shape of the relationship between density and recruitment is not known.

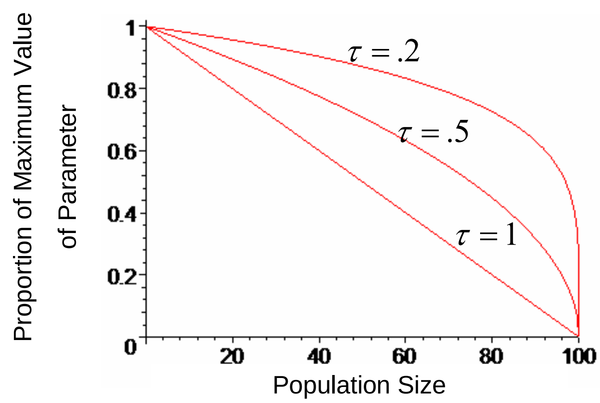


Figure 3. Illustration of model representation of non-linear density dependence for a hypothetical population with carrying capacity = 100 animals.

Dynamics of fertile females are specified by:

$$J_{t+1} = f(Y_t, A_t, N_t)r - H_{Jt} - C_{Jt}$$
$$H_{Jt} = f(Y_t, A_t, N_t)rh$$
$$C_{Jt} = f(Y_t, A_t, N_t)r(1-h)c$$

$$Y_{t+1} = J_t s_J \left(1 - \frac{N_t}{k_s}\right)^{\tau} - H_{Yt} - C_{Yt}$$

$$H_{Yt} = J_t s_J \left(1 - \frac{N_t}{k_s}\right)^{\tau} h \qquad (2)$$

$$C_{Yt} = J_t s_J \left(1 - \frac{N_t}{k_s}\right)^{\tau} (1-h)c$$

$$A_{t+1} = (A_t + Y_t)s_A - H_{At} - C_{Yt} + s_A(1-h)(1-c)I_{4t}$$
$$H_{At} = (A_t + Y_t)s_A h$$
$$C_{At} = (A_t + Y_t)s_A(1-h)c.$$

The state variable J_t represents the number of female fawns at time *t*. The state variable I_{4t} gives the number of animals treated with finite duration contraceptives that would have become fertile in the absence of treatment. The decision variable H specifies the number of animals culled from the population during time *t* to *t+1* ,while the decision variable *C* gives the number of animals treated with contraceptives during that interval. Subscripts on these terms index the stage (juvenile, yearling, adult) and the year. So, for example, C_{At} gives the number of adult females that are treated with contraceptives during time *t* to *t + 1*.

Dynamics of the male portion of the population resemble those of the females:

$$J'_{t+1} = f(Y_t, A_t, N_t)r - H_{J't}$$
$$H_{J't} = f(Y_t, A_t, N_t)(1-r)h$$
$$Y'_{t+1} = J'_t s_J \left(1 - \frac{N_t}{k_s}\right)^{\tau} - H_{Y't}$$
$$H_{Y't} = J'_t s_J \left(1 - \frac{N_t}{k_s}\right)^{\tau} h \qquad (3)$$
$$A'_{t+1} = (A'_t + Y'_t)s_A - H_{A't}$$
$$H'_{A't} = (A'_t + Y'_t)s_A h.$$

Where each stage is as defined above, with ‘ indexing males.

If animals are treated with contraceptives then infertile females must be represented in the model. When the effect of contraceptives is permanent, the number of infertile animals (I_t) is the population is estimated as

$$I_{t+1} = \left[\left(1 - \frac{C_{Jt}}{I_t}\right)s_A + \frac{C_{Jt}}{I_t}\left(1 - \frac{N_t}{k_s}\right)^{\tau} s_J\right] I_t + C_{Jt} + C_{Yt} + C_{At}\,. \qquad (4)$$

Where I_t is the number of infertile females at time *t* and the *C'*s give the number of animals treated in each age class during time *t* to *t + 1*. Note that this formulation accounts for difference in survival between juveniles and yearlings/adults by weighting the survival rate of juveniles and older animals by their proportions in the infertile stage.

When the effects of contraceptives are temporary, then we must keep track of the time since the animal was treated. This is done as follows:

$$\begin{aligned}
I_{1,t+1} &= C_{Jt} + C_{Yt} + C_{At} + C_{I_4 t} \\
I_{2,t+1} &= I_{1,t}\left[\left(1-\frac{J_t}{N_t}\right)s_a + \frac{J_t}{N_t}s_{Jt}\left(1-\frac{N_t}{k_s}\right)^{\tau}\right] - H_{I_1 t} \\
H_{I_1 t} &= I_{1,t}\left[\left(1-\frac{J_t}{N_t}\right)s_a + \frac{J_t}{N_t}s_{Jt}\left(1-\frac{N_t}{k_s}\right)^{\tau}\right]h \\
I_{3,t+1} &= I_{2,t}s_A - H_{I_2 t} \\
H_{I_2 t} &= I_{2,t}s_A h \\
I_{4,t+1} &= I_{3,t+1}s_A - H_{I_3 t} - C_{I_4 t} \\
H_{I_3 t} &= I_{3,t}s_A h \\
C_{I_4 t} &= I_{4t}s_A(1-h)c.
\end{aligned} \tag{5}$$

I assume that animals that are infertile and will not become fertile during time *t* to *t+ 1* (i.e., $I_{1t,}I_{2t},I_{3t}$) are not treated with contraceptives because treatment occurs every 4 years. Again, the *C's* give the number animals that are treated during time *t* to *t+1*. Each *C* is indexed by stage and time, so, for example C_{jt} gives the number of juveniles treated during time *t* to *t+1*. Note that $C_{I_4 t}$ gives the number of animals that were infertile at time *t* and that were prevented from becoming fertile at time *t+1* by treatment.

The total population size is the sum of the stages described above,

$$N_t = J_t + Y_t + A_t + J'_t + Y'_t + A'_t + \sum_{i=}^{4} I_{i,t}\,. \tag{6}$$

The lifetime effect model eliminates 3 infertile stages, replacing them with a single stage that does not return to the fertile adult stage (Figure 2). The single year duration model is identical to the lifetime effects model except that all infertile animals that are not treated return to the fertile adult stage during each time step.

Estimating Model Parameters

Demographic data on the Point Reyes Fallow deer population lack detail and depth, and as a result, we must rely on coarse estimates of parameters to allow simulation of the population's dynamics. Because these estimates are imprecise it will be important to incorporate appropriate uncertainty in model predictions to reflect uncertainty in parameter estimates. Procedures for uncertainty estimation will be discussed in a later section; here I describe procedures for determining best, educated guesses at parameter values.

Parameters controlling density dependent relationships are the most difficult to estimate, but current data allow approximations. Staring with the density dependent relationship controlling recruitment, I estimated m_A and m_Y loosely from allometric relationships for reproductive rates of ungulates. The parameter k_s represents the population size at for which recruitment = 0. (Note that this is not the conventional definition of ecological carrying capacity, which is the population size at which $N_t / N_{t+1} = 1$. Instead, ecological carrying capacity in this model depends on the interplay between k_m and k_s.) We can approximate k_s as follows. We start with the expression for juvenile females, assuming linear density dependence (e.g., $\tau = 1$) and culling and contraception rates = 0:

$$J_{t+1} = s_A(m_A F_t + m_Y Y_t)\left(1 - \frac{N_t}{k_m}\right) r \,. \tag{7}$$

Dividing both sides by $s_a(F_t + Y_t)$ we obtain:

$$\frac{J_{t+1}}{s_A(F_t + Y_t)} = \frac{(m_A F_t + m_Y Y_t)\left(1 - \frac{N_t}{k_m}\right) r}{(F_t + Y_t)}. \tag{8}$$

We don't know F_t or Y_t, but for the problem at hand, we simply need to know $\frac{Y_t}{F_{tt}}$. If we know the ratio of yearling females to adult females, in the population then we can scale the $F_t + Y_t$ term using that ratio by allowing F_t.=1. For example, if there are 25 yearling females per 100 adult females then the scaled sum of $F_t + Y_t$ is 1.25.

The left hand side of this expression is the ratio of juveniles (males and females) to surviving adult females, which is quite analogous to the fawn/doe ratios observed in the fall. Using the average ratios from the last 3 years (=.379), setting N_t = 800 based on the 2002 census, assuming that the sex ratio of offspring is .5, and risking the decidedly heroic assumption that half of the fawns observed in fall counts are female (i.e., J_{t+1} = fawn count*/2)* we obtain an equation with one unknown, k_m. Solving gives us k_m = 1487.

We can use similar logic to estimate k_s.. Assuming linear density dependence, the expression for juveniles surviving to become yearlings is

$$Y_{t+1} = J_t s_J \left(1 - \frac{N_t}{k_s}\right) \,, \tag{9}$$

which on rearrangement gives us the ratio of yearlings to juveniles at the time of census as a function of N_t and k_s:

$$\frac{Y_{t+1}}{J_t s_J} = \left(1 - \frac{N_t}{k_s}\right) \tag{10}$$

I assumed above s_J = .90, which is a very reasonable guess for populations at low density. (Remember that s_J cannot exceed 1, so it's upper value is constrained.) Equipped with that informed guess and knowing the ratio of yearlings to juveniles at t and N_t from data we again arrive at an equation with a single unknown, k_s. Solving provides k_s = 3600. We would expect this value to be higher than k_m because recruitment to age 8 months in ungulates is likely to be much more sensitive to density than their survival thereafter.

Adult survival was assumed to be constant and high, an assumption that has strong support in data for ungulates in general, even if we lack those specific data for fallow deer at Point Reyes.

Management Scenarios

Model runs were designed to represent two management alternatives. The first alternative was to eradicate fallow deer from Point Reyes during the next fifteen years. The second alternative was to reduce the population to 350 animals, including 50 fertile females over the same time interval. For each of these alternatives, I also I evaluated 5 control scenarios: fertility control alone, culling alone, and culling combined with treatment of 25%, 50% and 75% of surviving fertile females with contraceptives. Within each of the fertility control scenarios, I evaluated effects of duration of contraceptives by assuming that a single dose rendered an animal infertile for its lifetime, for 4 years, or for a single year. Current contraceptive technology provides one year of infertility per dose, however, fertility control agents lasting 4 years and agents sterilizing the animal for life are likely to be available for research applications during the next 2 years.

I assumed that fertility control agents were delivered to all ages in the population every 4 years beginning at year 0. Culling was assumed to start in year 1. I evaluated two culling regimes, which I will refer to as Fertiles Only and Females Only. In the Fertiles Only culling regime, I assumed that that only fertile females would be culled during the first ten years of the simulation. This means that animals treated with contraceptives would be marked so that infertile animals and males would be recognizable and would *not* be culled. In the Females Only culling regime, I assumed that only females would be culled during the first 10 years of the simulation. This means that animals treated with contraceptives would not need to be marked and would be culled along with fertile animals. In both regimes, I assumed that culling became indiscriminate after year 10, allowing males as well as fertile and infertile females to be culled.

Simulated control regimes assumed that a fixed *proportion* of animals would be treated or culled annually, rather than a fixed *number* of animals. The primary motivation for this approach was to represent what could be realistically achieved with a fixed annual investment in control efforts. Given a fixed amount of time allocated to finding and treating or culling animals, the number of animals treated or culled will assuredly decline as the population size declines. This is the case because the encounter rate with deer will diminish as the population is reduced, requiring more investment of time per animal treated or culled. Control efforts aimed at a fixed proportion of animals provide a diminishing target number of animals as the population is reduced and in so doing accommodate the increased amount of time that must be invested per deer treated or culled.

I did not evaluate a purely indiscriminate culling regime where all sexes and ages were culled during all years because I assumed that culling males from the outset would diminish the density dependent effects of males on female reproduction and survival and, hence, would increase the number of animals that must be culled. This assumption was verified by preliminary simulations—approximately 30% more animals would need to be culled to eradicate the population if culling was not selective for females in the first 10 years of the eradication effort.

To evaluate efficacy of fertility control alone, I predicted the population size at the end of 15 years assuming that 75% of the females could be treated every 4 years, which was judged to be the maximum possible delivery rate given logistic and financial constraints.

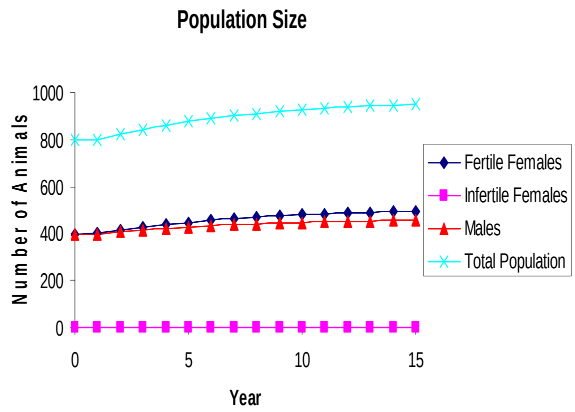


Figure 4. Trajectory of population growth of the Point Reyes fallow deer population in the absence of culling or fertility control.

Model Implementation

Equations outlined above were coded in Visual Basic for Applications running under Microsoft Excel. I used non-linear gradient search techniques to find culling rates that minimized the number of animals culled and treated with contraceptives subject to two constraints: that no more than half of the target population can be culled during any single year and that the population must number fewer than 5 animals 15 years after initiating treatment.

Results: Eradication Alternative

Population Trajectory in Absence of Control Efforts
Deterministic model runs in the absence of any culling or fertility control suggested that the current population is slightly below ecological carrying capacity and will continue to grow to a steady state of approximately 1000 animals (Figure 4). This estimate is reasonably close to the estimate obtained by (Gogan et al. 2001), and although both estimates could be wrong, it is reassuring that two different approaches to estimating carrying capacity yielded similar results.

It is imperative to understand that these results depend on the assumption that the Point Reyes fallow deer population is “closed” , which is to say that there is no emigration from the population to the surrounding area. This simplifying assumption is necessary to because we lack the data needed to model movement out of the park to the adjacent landscape. However, it is virtually certain that such movement would occur.

Effects of Fertiles Only Culling With and Without Fertility Control
Simulations of culling alone and culling in combination with fertility control indicated that the population could be eradicated within 15 years (Figure 5), but the effort required to achieve eradication differed among management scenarios. Culling alone required killing 653 animals over the course of the 15 year campaign (Figure 6). Combining culling with fertility control reduced the numbers of animals that would need to be culled, but increased the total number of animals that would need to be treated or culled (Figure 6). The extent of reduction in culling declined with declining duration of the contraceptives; the greatest reductions were achieved by delivering lifetime effect contraceptives. The smallest reductions occurred in simulations of single year duration contraceptives (Figure 6).

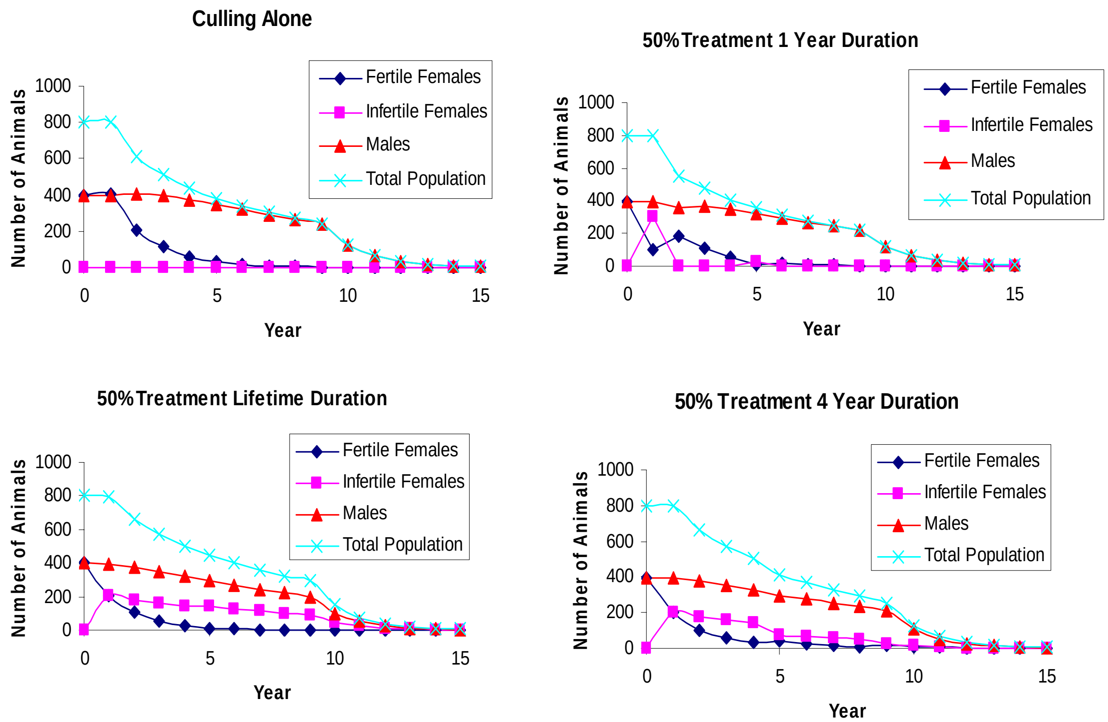


Figure 5. Simulated trajectories of fallow deer populations under four eradication regimes assuming only fertile females were culled before year 10. Shapes of curves for the .25 and .75 treatment levels closely resembled those shown here. Simulations assumed that infertile animals were marked and that only fertile females were culled during years 0-10. Thereafter, culling included males as well as fertile and infertile females.

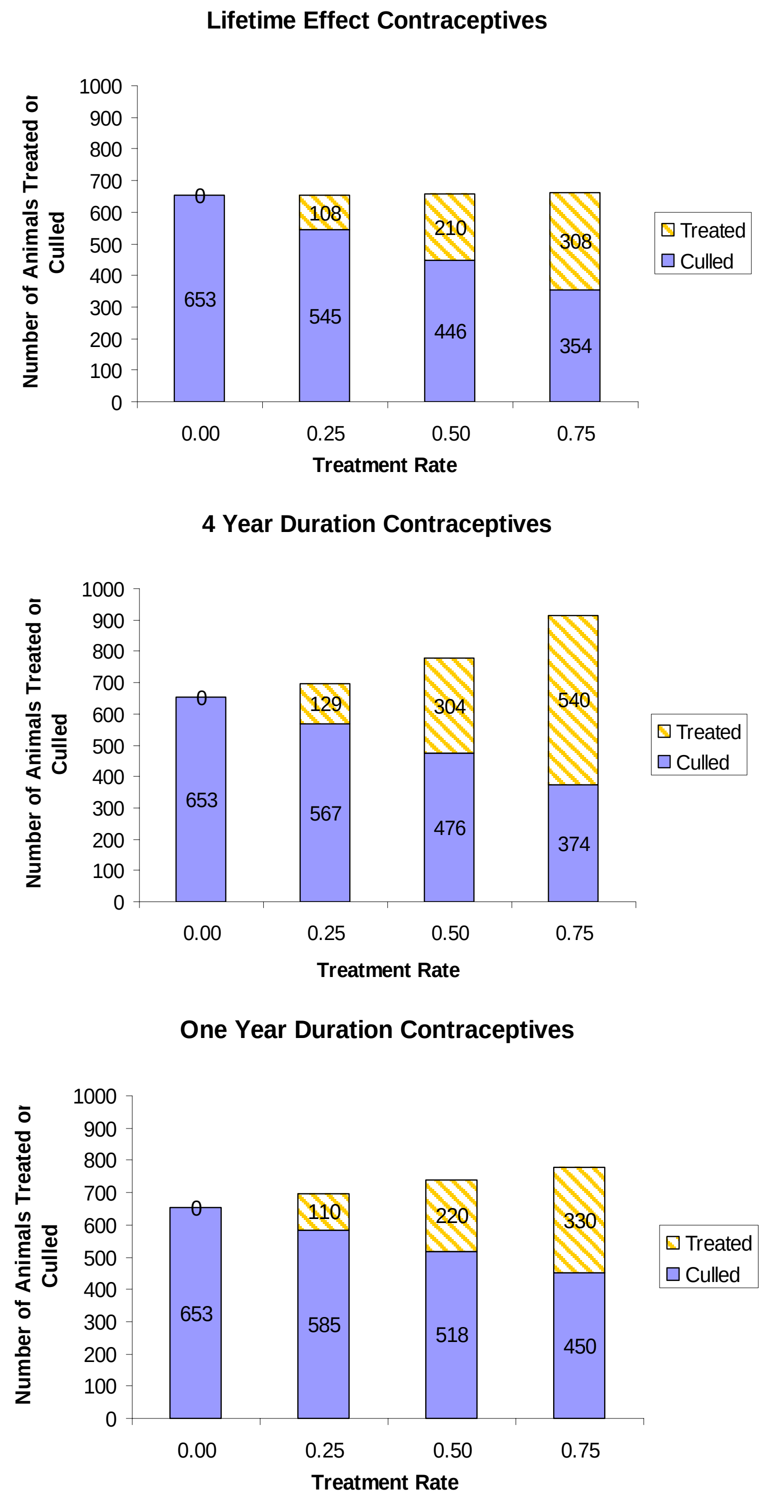


Figure 6. Total number of animals treated and/or culled during simulated 15 year campaign to eradicate fallow deer at Point Reyes National Seashore.

When culling was combined with fertility control, the total number of animals treated + culled was smallest for regimes using lifetime effect contraceptives and largest for regimes using 4 year duration contraceptives (Figure 6). The seeming efficiency of the single year duration contraceptives resulted from effects of culling early in the simulation (Figure 7, Appendix Tables 1-3). High levels of culling were possible in the early years of single year duration simulations because animals became fertile after one year and, hence were vulnerable to culling under the Fertiles Only culling regime. In contrast, animals treated with longer lasting agents would not be culled. The rapid decline in females resulting from culling in the single year duration simulations explains the greater requirement for culling in these simulations and the lower requirement for culling + treatment relative to the 4 year duration simulations (Figure 6, 7).

Virtually all treatment with contraceptives occurred during the first delivery period for the lifetime effect and single year duration contraceptives (Figure 7, Appendix Tables 1-3). This occurred because few fertile females remained the population by year 4 of the simulation, when the next fertility control treatment occurred. In the lifetime duration case, the absence of fertile females in year 4 occurred because the initial treatment and subsequent culling of the untreated portion of the population eliminated fertile females. In the single year duration case, the low numbers of fertile females in year 4 resulted because all females became vulnerable to culling after the first year of the simulation and most were killed before the next scheduled treatment with contraceptives. There were 3 significant treatments with contraceptives for the 4 year duration agents during year 0, 4, and 8. Multiple treatments were required for 4 year duration agents because 1) animals had to be retreated every 4 years to maintain infertility and 2) during the 4 year interval between treatments they were not vulnerable to culling under the Fertiles Only culling regime.

Simulations revealed that attempting to eradicate the population using fertility control alone is futile. Treatment of 75% of the females with single year duration agents every 4 years allowed the population to *increase* slightly. Although longer duration agents reduced the population substantially, they failed to achieve eradication even after 4 treatments applied over 15 years (Table 2). The inability of fertility control alone to reduce the population is easy to understand. Even when 100% of the females are maintained infertile, the maximum rate of decline of the population is no greater than the maximum mortality rate, which, in a long lived species like fallow deer, is quite small, approximately 10% per year.

Table 3. Results of simulation of eradication efforts using fertility control alone. Simulations assumed treatment of 75% of fertile females during years 0, 4, 8, and 12.

	Duration of Contraceptive		
Simulated Response	1 year	4 years	Lifetime
Population during year 15.	884	420	259
Total number of females treated	1318	922	439

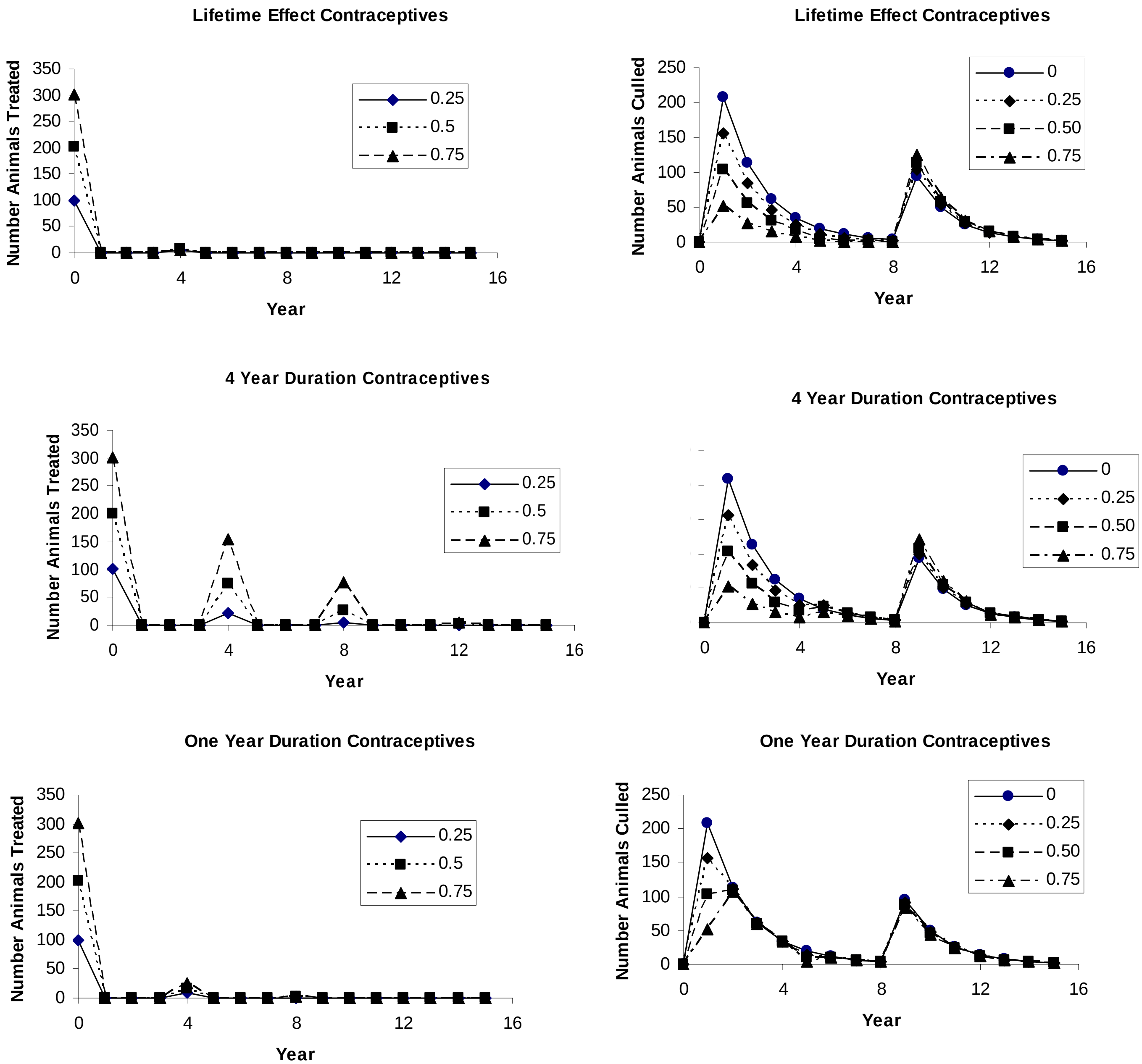


Figure 7. Number of animals annually treated (left column) or culled (right column) during simulated 15 year campaign to eradicate fallow deer at Point Reyes National seashore.

Uncertainty in model predictions was assessed for culling and culling combined with lifetime and 4 year duration contraceptives using Monte Carlo Simulation. This is a technique that uses multiple model runs to estimate the error in model output based on assumptions about the uncertainty in model input. For each model run, input values are chosen randomly for a distribution of potential parameter values. The results of these many runs are accumulated allowing calculation of means and confidence intervals on all model predictions.

Distributions of model parameters were chosen to allow for relatively high levels of uncertainty. (Table 3), thereby providing conservative (broad) confidence intervals on model predictions. Initial conditions for numbers of animals in each age/sex class were estimated by simulating density dependent population growth starting with a population of 20 males and 20 females and allowing the population to grow until it reached a size determined by a random variable drawn from a normal distribution with a mean equal to the current population size and a standard deviation equal to 20% of the mean.

Mean values of model predictions of number of animals treated and culled were calculated as the average of 100 replicate runs. Confidence intervals were estimated from the upper and lower .025 percentiles of the 100 replicates.

Table 4.

Model Parameter	Distribution	Distribution Parameters
Initial N	Normal	Mean = 800, standard deviation = 160
□	Uniform	lower = .5, upper = 1
s_A	Uniform	lower = .85, upper = .95
s_j	Uniform	lower = .85, upper = .95
m_a	Uniform	lower = .85, upper = .95
m_J	Uniform	lower = .45, upper = .55

Monte Carlo simulations provided reasonable confidence in estimates of the number of animals that would need to be treated or culled to eradicate the population within 15 years assuming the treatment regimes described in the results of deterministic simulations above (Table 5). The means shown in Table 5 do not perfectly match the predictions of the deterministic simulations (Figure 6) because the model is non-linear and stochastic results from non-linear models will not match deterministic results. Moreover the deterministic simulations assumed linear density dependence (i.e., $\tau = 1$) while the Monte Carlo simulations allowed for non-linear density dependence (i.e., $\tau < 1$).

Table 5. Means and 95% confidence intervals for model predictions of the number of animals treated with contraceptives and culled in simulations of a 15 year campaign to eradicate fallow deer from Point Reyes National Seashore.

		Number Treated			Number Culled		
Duration of Contraceptive	Proportion Fertile Females Treated	Mean	95% CI		Mean	95% CI	
4 year	0	0	0	0	677	426	924
	0.25	133	85	176	595	366	848
	0.5	327	219	442	530	324	775
	0.75	570	362	731	409	217	619
Lifetime	0	0	0	0	693	453	988
	0.25	134	89	181	604	349	866
	0.5	306	199	398	486	291	709
	0.75	553	361	795	395	221	709

Effects of Females Only Culling With and Without Fertility Control

Culling fertile and infertile females (but not culling males) substantially reduced any benefits of fertility control. Under this scenario, virtually all reductions in animal numbers resulted from culling. Duration of effects of contraceptives did not modify this result.

Results: Reduce Population to 350 Alternative

Effects of Fertiles Only Culling With and Without Fertility Control

Simulations of culling alone and culling in combination with fertility control indicated that the population could be reduced to 350 animals (including 50 fertile females) within 15 years, but the effort required to achieve this reduction differed among management scenarios. Culling alone required killing 452 animals over the course of the 15 year campaign (Figure 8). Combining culling with fertility control reduced the numbers of animals that would need to be culled, but markedly increased the total number of animals that would need to be treated or culled (Figure 8). The extent of reduction in culling declined with declining duration of the contraceptives; the greatest reductions were achieved by delivering lifetime effect contraceptives. The smallest reductions occurred in simulations of single year duration contraceptives (Figure 8).

When culling was combined with fertility control, the total number of animals treated + culled was smallest for regimes using lifetime effect contraceptives and largest for regimes using 4 year duration contraceptives (Figure 8). The seeming efficiency of the single year duration contraceptives resulted from effects of culling early in the simulation (Figure 9).

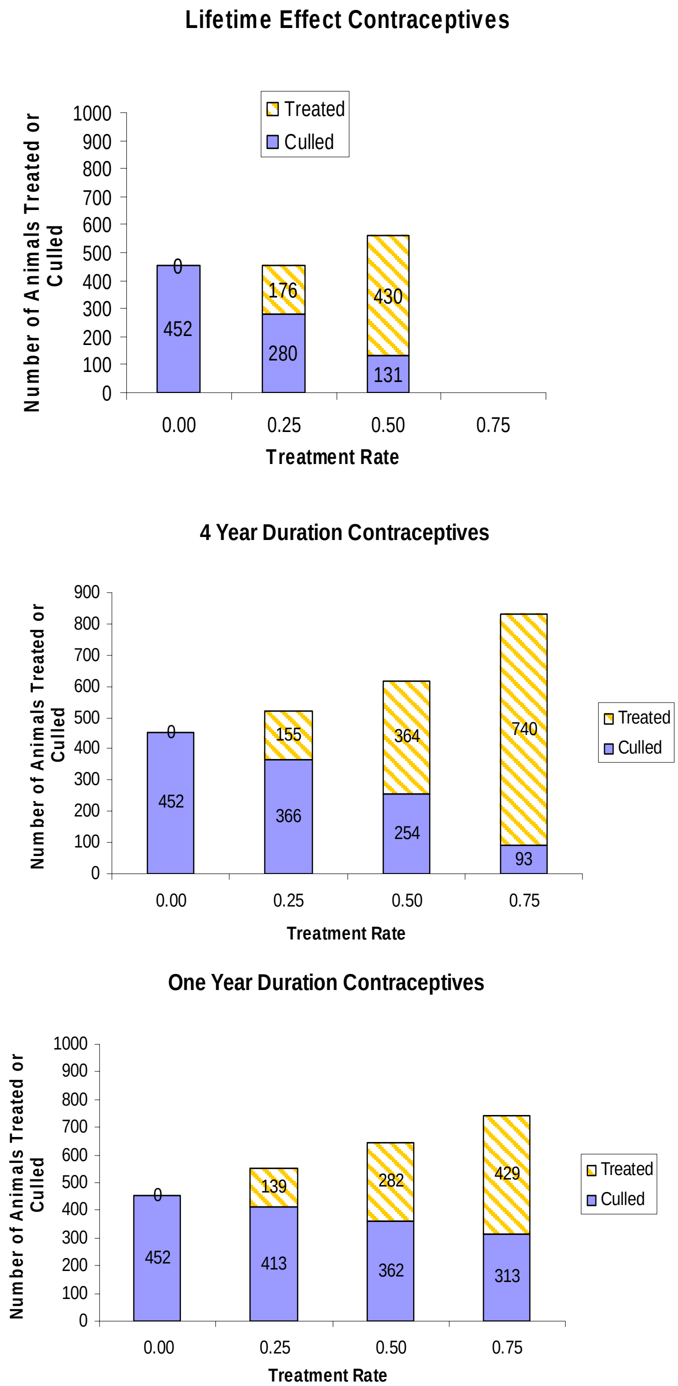


Figure 8. Total number of animals treated and/or culled during simulated 15 year campaign to reduce the fallow deer population at Point Reyes National Seashore to 350 animals in and total fertile females = 50. It was not feasible to treat 75% of the fertile females and maintain 50 fertile

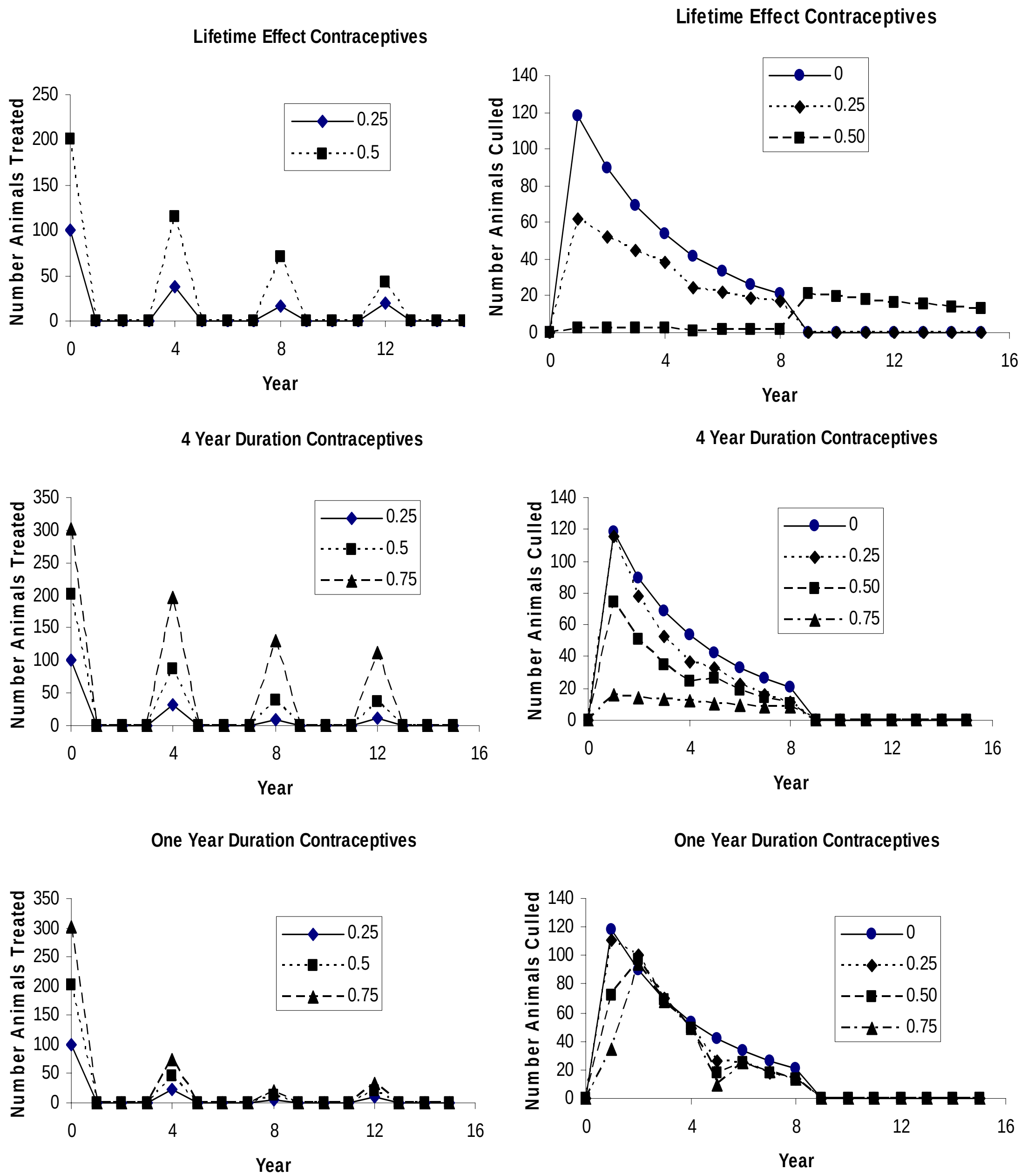


Figure 9. Number of animals annually treated (left column) or culled (right column) at Point Reyes National seashore during simulated 15 year campaign to reduce the fallow deer population to 350 animals, including 50 fertile females. The data in these plots are tabulated in Appendix Tables 4-6.

Discussion

Simulation modeling revealed that a sustained effort could feasibly eradicate fallow deer from Point Reyes National Seashore. It would also be feasible to reduce the population to approximately half the current size. However, the amount of effort required to achieve the two population targets (0 or 350) was not proportionate to the magnitude of the reduction. I estimated that about 650 animals would need to be culled (assuming no fertility control) to eradicate the population, while only 200 fewer would need to be culled to reduce the population to 350 animals.

Although simulations portrayed a 15 year effort, results suggested that eradication in 10 years would be plausible if 50% of the fertile females could be culled annually (Figure 7, 9). Treating animals with contraceptives could substantially reduce the number of animals that would need to be culled if animals could be marked such that only infertile animals were culled in initial phase of reductions. If animals could not be marked, then fertility control had nominal effects on the number of animals culled. However, fertility control did not reduce the total number of animals that would need to be treated and culled, which means that it did not increase the efficiency of culling. The model strongly supported the logical contention that fertility control alone was not a feasible approach to eradication, even when using long duration contraceptives.

There are many uncertainties in the values of parameters used in the model, but error analysis suggested that while these uncertainties might change the quantitative results of simulation, the qualitative conclusions drawn from them remain robust. This means that the absolute number predicted by the model should be viewed with caution, but we can have substantial confidence in the conclusion that sustained efforts at eradication will achieve the desired result. It will be important that such efforts be conducted with careful attention to monitoring the population. Monitoring data should be analyzed with a model like this one, incorporating uncertainty, to guide control efforts. An effort to calibrate estimates of population size with catch per unit effort would likely prove extremely worthwhile over a 10 + year campaign.

Literature Cited

Gogan, P. J. P., R. H. Barrett, W. W. Shook, and T. E. Kucera. 2001. Control of ungulate numbers in a protected area. Wildlife Society Bulletin 29:1075-1088.

Hobbs, N. T., D. C. Bowden, and D. L. Baker. 2000. Effects of fertility control on populations of ungulates: General, stage-structured models. Journal of Wildlife Management 64:473-491.

Appendix Table 1. Simulated number of fallow deer treated with lifetime effect contraceptives and culled during 15 year eradication campaign at Point Reyes National Seashore.

	Treated				Culled			
	Proportion Treated				Proportion Treated			
Year	0	0.25	0.5	0.75	0	0.25	0.5	0.75
0	0	101	201	302	0	0	0	0
1	0	0	0	0	208	156	104	52
2	0	0	0	0	113	84	56	28
3	0	0	0	0	62	46	30	15
4	0	6	8	6	34	25	17	8
5	0	0	0	0	19	11	5	1
6	0	0	0	0	11	6	3	1
7	0	0	0	0	6	3	1	0
8	0	0	0	0	4	2	1	0
9	0	0	0	0	95	104	114	125
10	0	0	0	0	49	53	58	63
11	0	0	0	0	26	27	29	32
12	0	0	0	0	13	14	15	16
13	0	0	0	0	7	7	8	8
14	0	0	0	0	4	4	4	4
15	0	0	0	0	2	2	2	2
All years	0	108	211	309	653	545	446	354

Appendix Table 2. Simulated number of fallow deer treated with 4 year duration contraceptives and culled during 15 year eradication campaign at Point Reyes National Seashore.

	Treated				Culled			
	Proportion Treated				Proportion Treated			
Year	0	0.25	0.5	0.75	0	0.25	0.5	0.75
0	0	101	201	302	0	0	0	0
1	0	0	0	0	208	156	104	52
2	0	0	0	0	113	84	56	28
3	0	0	0	0	62	46	30	15
4	0	23	74	154	34	25	17	8
5	0	0	0	0	19	25	24	16
6	0	0	0	0	11	14	14	9
7	0	0	0	0	6	8	8	5
8	0	5	27	78	4	5	4	3
9	0	0	0	0	95	99	108	121
10	0	0	0	0	49	51	55	61
11	0	0	0	0	26	26	28	31
12	0	1	2	5	13	14	14	12
13	0	0	0	0	7	7	8	8
14	0	0	0	0	4	4	4	4
15	0	0	0	0	2	2	2	2
All years	0	129	304	540	653	567	476	374

Appendix Table 3. Simulated number of fallow deer annually treated with 1 year duration contraceptives and culled during 15 year eradication campaign at Point Reyes National Seashore.

	Treated				Culled			
	Proportion Treated				Proportion Treated			
Year	0	0.25	0.5	0.75	0	0.25	0.5	0.75
0	0	101	201	302	0	0	0	0
1	0	0	0	0	208	156	104	52
2	0	0	0	0	113	111	109	107
3	0	0	0	0	62	61	60	59
4	0	8	17	25	34	34	34	33
5	0	0	0	0	19	14	9	5
6	0	0	0	0	11	10	10	9
7	0	0	0	0	6	6	6	5
8	0	1	2	2	4	3	3	3
9	0	0	0	0	95	91	87	84
10	0	0	0	0	49	47	46	44
11	0	0	0	0	26	25	24	23
12	0	0	0	0	13	13	13	12
13	0	0	0	0	7	7	7	7
14	0	0	0	0	4	4	4	4
15	0	0	0	0	2	2	2	2
All years	0	110	220	330	653	585	518	450

Appendix Table 4. Simulated number of fallow deer treated with lifetime duration contraceptives and culled during 15 year campaign to reduce the population to 350 animals (including 50 fertile females) at Point Reyes National Seashore. It was not feasible to treat 75% of the fertile females and meet the target objectives.

	Treated			Culled		
	Proportion Treated			Proportion Treated		
Year	0	0.25	0.5	0	0.25	0.5
0	0	101	201	0	0	0
1	0	0	0	118	62	2
2	0	0	0	90	52	2
3	0	0	0	69	45	2
4	0	38	115	53	38	2
5	0	0	0	42	25	1
6	0	0	0	33	22	1
7	0	0	0	26	19	1
8	0	17	71	21	17	1
9	0	0	0	0	0	21
10	0	0	0	0	0	19
11	0	0	0	0	0	18
12	0	20	43	0	0	17
13	0	0	0	0	0	15
14	0	0	0	0	0	14
15	0	0	0	0	0	13
All Years	0	176	430	452	280	131

Appendix Table 5. Simulated number of fallow deer treated with 4 year duration contraceptives and culled during 15 year campaign to reduce the population to 350 animals (including 50 fertile females) at Point Reyes National Seashore.

	Treated				Culled			
	Proportion Treated				Proportion Treated			
Year	0	0.25	0.5	0.75	0	0.25	0.5	0.75
0	0	101	201	302	0	0	0	0
1	0	0	0	0	208	156	104	52
2	0	0	0	0	113	84	56	28
3	0	0	0	0	62	46	30	15
4	0	23	74	154	34	25	17	8
5	0	0	0	0	19	25	24	16
6	0	0	0	0	11	14	14	9
7	0	0	0	0	6	8	8	5
8	0	5	27	78	4	5	4	3
9	0	0	0	0	95	99	108	121
10	0	0	0	0	49	51	55	61
11	0	0	0	0	26	26	28	31
12	0	1	2	5	13	14	14	12
13	0	0	0	0	7	7	8	8
14	0	0	0	0	4	4	4	4
15	0	0	0	0	2	2	2	2
All years	0	129	305	540	653	568	476	374

Appendix Table 6. Simulated number of fallow deer treated with 1 year duration contraceptives and culled during 15 year campaign to reduce the population to 350 animals (including 50 fertile females) at Point Reyes National Seashore.

	Treated				Culled			
	Proportion Treated				Proportion Treated			
Year	0	0.25	0.5	0.75	0	0.25	0.5	0.75
0	0	101	201	302	0	0	0	0
1	0	0	0	0	118	111	72	35
2	0	0	0	0	90	100	97	94
3	0	0	0	0	69	70	69	68
4	0	23	47	74	53	50	50	50
5	0	0	0	0	42	27	18	9
6	0	0	0	0	33	25	25	25
7	0	0	0	0	26	18	18	19
8	0	6	13	21	21	13	14	14
9	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0
12	0	10	20	32	0	0	0	0
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0
All years	0	139	282	429	452	413	362	313

Appendix E: Section 7 Consultation, US Fish and Wildlife Service and National Oceanic and Atmospheric Administration

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825-1846

In Reply Refer to:
1-1-05-I-0035

April 7, 2005

Memorandum

To: Park Superintendent, Point Reyes National Seashore, National Park Service, Point Reyes, California (Attn: Ranger Natalie Gates)

From: Deputy Assistant Field Supervisor, Endangered Species Program, Sacramento Fish and Wildlife Office, Sacramento, California Cl Nagano

Subject: Concurrence with Not Likely to Adversely Affect Determination for Nine Listed Species and Proposed Critical habitat for the California Red-legged Frog as a result of the Non-Native Deer Management Plan at the Point Reyes National Seashore and Golden Gate National Recreation Area in Marin County, California

This memorandum is in response to the U. S. National Park Service's March 10, 2005, request for the concurrence of the U.S. Fish and Wildlife Service (Service) for the proposed Non-Native Deer Management project at the Point Reyes National Seashore and Golden Gate National Recreation Area in Marin County County, California. Your request was received by this Field Office on March 14, 2005. Additional information was received from the National Park Service in a letter to the Service dated March 30, 2005, that was received by us on April 6, 2005. At issue are the potential effects of the proposed project on the threatened California red-legged frog (*Rana aurora draytonii*), threatened western snowy plover (*Charadrius alexandrinus nivosus*), threatened northern spotted owl (*Strix occidentalis caurina*), endangered California freshwater shrimp (*Syncaris pacifica*), endangered Myrtle's silverspot butterfly (*Speyeria zerene myrtleae*), endangered Sonoma alopecurus (*Alopecurus aequalis* var. *sonomensis*), endangered beach layia (*Layia carnosa*), endangered clover lupine (*Lupinus tidestromii*), endangered Sonoma spineflower (*Chorizanthe valida*), and proposed critical habitat for the threatened California red-legged frog. This response is provided pursuant to section 7(a) of the Endangered Species Act, as amended (16 U.S.C. 1531 *et seq.*)(Act), and in accordance with the regulations governing interagency consultations (50 CFR § 402).

This document is based on your March 10, 2005, letter and associated information; your March 30, 2005, letter; *Point Reyes National Seashore Threatened and Endangered Species Locations as of 2001*, undated, that was prepared by the National Park Service; and other information available to the Service.

TAKE PRIDE IN AMERICA

It is our understanding the proposed project consists of the lethal removal and fertility control of all axis deer (*Axis axis*) and fallow deer (*Dama dama dama*) by the year 2020. A percentage of the fallow deer would be treated with an existing long-acting contraceptive, and both species of deer would be removed via shooting. The proposed management activities will take place in open flat grassland or scrub areas where deer can be safely handled for contraceptive administration or safely culled. No management activities will take place in creeks, waterways, or riparian areas. The culling would be conducted by National Park Service staff specifically trained in wildlife sharpshooting. Deer carcasses will be removed when possible; in cases where carcasses could not be accessed, they will be left in place to recycle nutrients into the ecosystem. Monitoring would continued until all non-native deer area eradicated by the year 2020.

The measures in the proposed project are sufficient to reduce any direct, indirect, and cumulative effects on the California red-legged frog, western snowy plover, northern spotted owl, California freshwater shrimp, Myrtle's silverspot butterfly, endangered Sonoma alopecurus, endangered beach layia, endangered clover lupine, endangered Sonoma spineflower to an insignificant or discountable level, or result in adverse modification or destruction of the proposed critical habitat of the California red-legged frog. Critical habitat for the other eight species has not been proposed, designed, or is located in the action area. Therefore, the Service concurs that the project, as described within your March 10, 2005, and March 30, 2005, letters and accompanying material, is not likely to adversely affect these nine listed species and proposed critical habitat for the California red-legged frog. If project work descriptions or time frames change, or were not evaluated, it is our recommendation that the changes be submitted for our review. This concludes our review of the actions outlined in the March 10, 2005, and March 30, 2005, letters and accompanying material, and no further coordination with the Service under the Act is necessary at this time. Please note that this memorandum does not authorize the take of listed species.

As provided in 50 CFR § 402.14, initiation of formal consultation is required where there is discretionary Federal agency involvement or control over the action (or is authorized by law) and if: (1) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this review; (2) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this opinion; or (3) a new species is listed or critical habitat designated that may be affected by the action.

We appreciate your proactive efforts to conserve and recover endangered species. Please contact Chris Nagano, Deputy Assistant Field Supervisor (Endangered Species Program), at the letterhead address or at 916/414-6600 if you have questions regarding this response.

cc:
Ranger D. Hatch, GGNRA, NPS, San Francisco, California
Ranger N. Hornor, GGNRA, NPS, San Francisco, California
Ranger D. Fong, GGNRA, NPS, San Francisco, California
Ranger S. Allen, PRNS, NPS, Point Reyes Station, California
Gary Fellers, USGS, Point Reyes Station, California

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802- 4213

RECEIVED
Point Reyes
National Seashore
MAY 3 - '05

May 3, 2005

In Response Refer to:
151422SRW05SR00250:DL

SUPT.
ASST. SUPT.
SPEC. PK. USES
LAW ENFORC.
RES./SCIENCE
RANGE CONS.
FIRE MGT.
INTERP.
CULT. RES.
MAINT.
CONTRACTING
PERSONNEL
BUDGET
CENTRAL FILES

Don L. Neubacher, Superintendent
National Park Service
Point Reyes National Seashore
Point Reyes, California 94956

Dear Mr. Neubacher:

This letter is in response to your request for written concurrence from the NOAA's National Marine Fisheries Service (NMFS) regarding the National Park Service's (NPS) three determinations related to its Non-native Deer Management Plan for the Point Reyes National Seashore: 1) the project is not likely to adversely affect threatened California Coastal (CC) Chinook salmon (*Oncorhynchus tshawytscha*), Central California Coast (CCC) coho salmon (*O. kisutch*), or CCC steelhead (O. mykiss); 2) the project is not likely to result in adverse effects to designated critical habitat for CCC coho salmon or the proposed critical habitat of CC Chinook salmon and CCC steelhead; and 3) the project is not likely to result in adverse modification of Essential Fish Habitat. NPS proposes to eradicate nonnative axis deer (*Cervus axis*) and fallow deer (*Cervus dama*) on its holdings throughout the Lagunitas Creek watershed in Marin County California. The proposed eradication efforts will occur in grassland or scrub areas where deer can be handled or culled safely. No management actions will occur in streams or riparian areas. Therefore, I concur with NPS's three determinations stated earlier in this paragraph.

This concludes informal section 7 consultation for this proposed project in accordance with 50 CFR section 402.14(b)(1). Consultation must be reinitiated if new information becomes available revealing the effects of the action on listed species in a manner or to an extent not previously considered, the project plans change, if the action is subsequently modified in a manner that causes an effect to listed species that was not considered, or if a new species or critical habitat is designated that may be affected by this action.

If you have questions concerning this consultation, please contact Daniel Logan at (707) 575-6053.

Sincerely,

for Rodney R. McInnis
Regional Administrator

cc: ARA-PRD, NMFS

Appendix F: Projects Considered in Cumulative Impacts Analyses

The projects listed here are past, present and reasonably foreseeable future actions at PRNS and the PRNS-managed lands of GGNRA considered by the Interdisciplinary Team (IDT) in assessing the cumulative impacts of the five analyzed alternatives. Cumulative impacts, or the combined incremental effects of human activities which may accumulate over time and affect resources, are discussed in Chapter 4, Environmental Consequences. In addition to the following projects, the IDT also considered interagency information and wider ranging issues such as human development, pollution, economic trends etc. in analyzing cumulative impacts.

Tule Elk Management. The 1998 *Point Reyes National Seashore Tule Elk Management Plan and Environmental Assessment* (NPS 1998) directs management of tule elk throughout the park. The plan includes:

- Maintaining viable populations of tule elk at PRNS (ongoing).
- Managing elk to regulate population size using minimal intrusion, where possible, as part of the natural ecosystem processes (i.e. natural regulation - ongoing).
- Establishing free-ranging tule elk in the park by 2005. (This objective was completed in 1999 with the relocation of 45 Tomales Point elk to the Limantour Wilderness Area (Phillip Burton Wilderness).
- Researching and monitoring the habitat and elk population over time (ongoing). This monitoring includes use of horses and aircraft for censuses and capture.
- Testing the efficacy of contraception for population control at Tomales Point. (This objective was completed in 2001).

The following is a summary of effects of the selected alternative from the 1998 Tule Elk Management Plan:

The maintenance and conservation of tule elk in Point Reyes National Seashore will have beneficial impacts by contributing towards ecosystem restoration of native fauna; will be compatible with protecting habitats for several endangered, threatened, and rare species and will assist in preventing impacts from overpopulation that could threaten biological diversity in native habitats.

Relocation of tule elk to other natural areas of the Seashore would not create any new zoning, land-use regulations, or changes to permitted uses. The relocation of tule elk and their subsequent dispersal would not impact private landowners or Seashore visitors. Local jurisdictions would be under no Service requirement to amend their land-use plans to conform with the project. Relocation of tule elk to other areas of the state would be conducted in cooperation with the California Department of Fish and Game, per subsequent CEQA process to be conducted by the State.

Managing elk using relocations and scientific techniques would not result in the displacement of ranching activities with the Seashore. Existing conditions would continue within the Seashore as a result of the ability to manage elk as described in the document.

The proposed action would have a short-term adverse effect by the limited use of motorized equipment in wilderness under the minimum tool concept. The localized use of helicopters or motor vehicles for short duration may have effects on wilderness users. Such transitory effects are deemed negligible and are clearly outweighed by the long term enhancement of this key attribute of the Seashore's wilderness.

Based on the analysis in the Environmental Assessment (NPS 1998) and the capacity of the mitigation measures to reduce or avoid potential impacts, the National Park Service determined that managing tule elk at Point Reyes National Seashore using relocations and scientific techniques was not a major Federal action that would significantly affect the quality of the human environment. The Plan was determined to have no major cumulative impacts.

Fire Management Program. In July 2004, Point Reyes completed a *Fire Management Plan (FMP) and Environmental Impact Statement for the Seashore and for the Northern District of Golden Gate National Recreation Area* (NPS 2004a). The plan provides a framework for all fire management activities within the Parks, including suppression of unplanned ignitions, prescribed fire, and mechanical fuels treatments. It is intended to guide the fire management program for the next 10-15 years. In accordance with NPS policy, the plan is responsive to the parks' natural and cultural resource objectives, reduces risk of fire to developed facilities and adjacent communities, and provides for public and staff safety. Up to 3,500 acres annually could be burned or mechanically treated over the next decade as a result of the Fire Management Plan.

A brief summary of the potential impacts from the approved FMP/EIS (NPS 2004a) follows.

Impacts to soils from the actions anticipated include changes in soil productivity and chemistry, as well as erosion following the removal of vegetation. The impacts on soils from increased erosion of prescribed burning and average wildland fires (no more than about 30 acres per year) under the selected alternative would be negligible to minor. Moderate to major, short to long term, adverse cumulative impacts to the physical, chemical, and biological properties of soils from a very large or catastrophic wildland fire are possible under the selected alternative. Suppression activities could have additional adverse, short to long-term moderate to major impacts from soil compaction, mixing, reduced infiltration, loss of vegetation, and changes in soils that prevent quick revegetation. Actively suppressing wildland fires before they reach sensitive resources could keep impacts from becoming major and adverse.

$PM_{2.5}$ (particulates less than 2.5 microns in size)is the air quality parameter measured at PRNS, and the park is well below state and federal standards. Other air pollutants are not measured in the study area, so those from the closest rural locations (Santa Rosa and Vallejo) were used as an approximation. Santa Rosa meets the federal average standard for particulates smaller than 10 microns, but is higher than California's more strict standards. It is well below both the maximum one-hour and eight-hour average federal and state standards for carbon monoxide, and the state and federal one-hour (state) and annual average (federal) standards for nitrogen dioxide. Vallejo is also well below the federal and California maximum 24-hour and annual average standards for sulfur dioxide. Santa Rosa has exceeded the state's maximum 24-hour ozone average of 50 $\mu g/m^3$ twice over the three-year period measured, and the California one-hour ozone standard once.

On an annual basis, the selected alternative would generate particulate emissions into the air. This is because of the number of acres treated with prescribed fire each year and the potential treatment of forested acres, which produce the highest emission levels. The selected alternative would produce an average 5.3 pounds of PM_{10} per acre managed, resulting in a long-term, adverse, moderate effect on regional haze. This additional contribution would be offset by the long-term opportunity presented by this alternative to achieve a major, beneficial, cumulative effect on regional haze by reducing the risk of a catastrophic fire. Nuisance smoke would be an infrequent, short-term, adverse, negligible to moderate air quality impact for residents near prescribed burns during the duration of the burn.

In the context of the 90,000 acre study area, the impacts to water quality and watershed characteristics would provide a combined moderate to major benefit to watersheds through the use of prescribed burning and mechanical treatment to reestablish natural hydrological processes and reduce the potential for catastrophic wildfire. The selected alternative would result in minor, adverse, short-term impacts to water quality from ash or increases in erosion and suspended solids.

In areas treated with prescribed fire, minor, short-term adverse impacts associated with loss of vegetation, as well as the possibility of introduction or spread of non-native plants would occur. However, the burns also would result in minor to moderate beneficial impacts as burning would stimulate growth of many native plant species, and would eliminate non-native vegetation.

Mechanical fuel reduction would have minor short-term adverse impacts on native vegetation through crushing or other physical impacts, but clearing of dense vegetation also would have possibly long-term, minor to moderate benefits on most plant communities as well. In light of observed consumption by non-native deer of rare bulb species after the 1995 Mount Vision fire, grazing pressure on Fritillaria sp. and other rare species in burned areas could increase after prescribed burns.

The selected alternative will result in minor to moderate localized benefits to native vegetation from the removal of non-native Monterey pine and cypress trees. For these beneficial impacts to persist, however, follow-up activities must be conducted to remove new recruits that come into the site in years following prescribed burning or mechanical treatments.

The selected alternative will have short-term, minor adverse impacts from unintentional burning of vegetation, especially in dry years. However, research and observations at the Seashore indicate wetland vegetation can be thinned and stimulated to reproduce by low or moderate intensity fires. These same fires can destroy non-native plants in wetlands. Minor to moderate short to long-term benefits to wetland vegetation from prescribed burning or even small wildfires are therefore possible. For both adverse effects and beneficial effects, the degree of impact is greater when more acreage is treated.

Some wildfire suppression activities or actions to control prescribed burns, such as spike camps, access or creating fire lines, would have minor short-term adverse impacts on wildlife. Other activities, such as creating helispots or the use of helicopter buckets of water or retardants, may have longer lasting adverse impacts. Overall, these activities are not expected to have more than minor adverse impacts to wildlife.

Treatment with prescribed fire and through mechanical means in the selected alternative would result in short to long-term, minor to moderate benefits to wildlife from the reestablishment of the natural fire cycle, reduction of fuel loads, and reduction of the potential for catastrophic wildfire. In the context of the entire study area, The FMP would result in minor short to long-term benefits to wildlife from creating open habitat.

The FMP will result in moderate short-term benefits to historic buildings by reducing fuels around these structures, both through prescribed burns and mechanical treatment. There would be moderate long-term benefits to cultural landscapes from restoration or maintenance through prescribed fire or mechanical treatments. The FMP could have negligible to major adverse impacts on cultural resources, including historic structures and archeological resources, from suppression activities associated with even average sized wildfires. Impacts to cultural landscapes, however, would be minor to moderate, as only a small portion of the landscape would be burned. Larger wildfires would be much more likely to result in major permanent adverse impacts from the burning of historic structures, damage to buried resources, and the loss of a significant portion of cultural landscapes.

Prescribed burning would have minor beneficial effects by opening and restoring scenic vistas, but also short-term adverse effects on some visitor activities from blackening of vegetation with prescribed fires. The impact would be adverse and moderate and may last up to 50 days per year.

Mechanical treatment may adversely affect park visitors through noise and closures. Impacts would be short-term and moderate.

An overall 5.9% increase in budget and additional 5 FTEs in staffing required in the FMP to conduct additional prescribed burning and thinning would have minor adverse impacts to park operations and management.

The actions in the FMP will have direct adverse, short-term and minor impacts upon the health and safety of both the public and firefighters, except during large, high severity fire events, when the proximity of people to smoke and flame would result in major, short-term, and unavoidable adverse impacts.

Direct fire funding and staffing would have long-term, beneficial impacts compared to dollars and staff positions generated from tourism in the local economy. These benefits would be minor.

Giacomini Wetlands Restoration. The proposed Giacomini Restoration is described in a separate Giacomini Restoration Plan, Environmental Impact Statement to be released in 2006. The following information is from the Giacomini Wetlands Restoration Project, Project Description (NPS 2005).

The project is to restore 550 acres of wetlands at the head of Tomales Bay within Golden Gate National Recreation Area. The area is administered by Point Reyes National Seashore. The project would restore processes and functions to an area that represents as much as 12 percent of the wetlands present along the outer central California coast. More than 60 percent of the Tomales Bay vegetated intertidal wetlands were lost in the 1940s with diking of a 550-acre historic coastal marsh for a dairy operation. Wetlands play an important role in watershed health through functions such as nutrient and sediment retention. These functions are particularly important in Tomales Bay, which has been declared impaired by the Regional Water Quality Control Board for sediment, nutrients, pathogens, and mercury.

With this project, the National Park Service will restore natural tidal wetlands and associated functions to the Project Area, which it purchased in 2000. Restoring connectivity between Tomales Bay, Lagunitas Creek, and the active floodplain will improve water quality not only within the Project Area, but within the entire Bay.

Alternatives include both restoration and public access components, with restoration involving some degree of topographic and hydrologic alteration aimed at increasing or enhancing hydrologic connectivity, native vegetation, and habitat for common and special status wildlife species.

The project area is bisected by Lagunitas Creek. This property, once tidal wetlands, was diked and drained in the early 1940s to create pastures. For many years, a gravel dam was constructed annually just below the confluence of Lagunitas and Olema creeks for irrigation and stock watering. The dam created an abrupt transition from fresh to saline water for smolts and spawning adults, eliminating the transition zone found in an unimpaired estuarine system. The dam and the levees concentrated the area where spawning fish could remain and smolts could feed, and increased the potential for predation. A transition zone would allow smolting fish time to adjust to saline conditions and provide productive feeding zones where both freshwater and saltwater invertebrates are available. While the annual construction of the dam has been discontinued, the levees are still in place. Restoration is planned to begin after final acquisition in 2007.

The anticipated primary impacts of this project are:

Restored wetlands will not only filter nutrients, contaminants, and sediment in freshwater inflows from Lagunitas, Olema, and Bear Valley Creeks, but provide a source of food for estuarine and marine wildlife species for export to the Bay. Restoration of pasture to wetlands will also increase breeding, rearing, foraging, and refugia habitat for numerous common and special status wildlife species. In addition, hydrologic modeling indicates that the proposed restoration alternatives would have a considerable beneficial impact on flooding of adjacent properties and county roads, thereby supporting the Park Service's contention that restoration will improve wetland functions such as floodwater retention.

Some of the possible negative impacts of the proposed project include effects to special status species habitat. Increasing tidal influence has the potential to negatively affect populations of California red-legged frog (federally threatened) and tidewater goby (federally endangered). Also, removal of the levees could eliminate high-tide refugia for rails such as the California clapper rail (federally endangered) and California black rail (state threatened).

The project is proposing to create freshwater marsh habitat for the California red-legged frog near Tomasini Creek (Tomasini Triangle) in the East Pasture, thereby mitigating impacts to habitat in the West Pasture from increased tidal influence. Existing habitat for the tidewater goby will be maintained after restoration to allow time for new habitat to develop within the restored pasturelands. In addition, any impacts to rails will be mitigated by creating high-tide refugia.

The project would enhance water quality by creating a marsh filtration system and would increase natural resource protection over a local area, but would enhance the entire Tomales Bay area; therefore impacts would be beneficial and moderate for water quality.

The project would have minor beneficial effects on wildlife, by providing additional coastal habitat. The project's effects on vegetation, especially the creation of new wetlands, would be moderate because the project would restore an area that represents as much as 12 percent of the wetlands present along the outer central California coast. In addition, it would restore a major wetland that was lost on Tomales Bay in the 1940s with diking of a 550-acre historic coastal marsh for a dairy operation. Additional benefits to plants and wildlife would come from proposed riparian, native grassland, and marsh revegetation activities within selected portions of the East and West Pasture Project Areas.

Habitat for several listed species, including coho salmon and steelhead trout, would be improved. Therefore, because the effects could increase these species, the effects would be moderate and beneficial.

Dairy and Beef Ranching. Ranching on within NPS boundaries pre-dates the park and is specifically mentioned in the enabling legislation and general management plans of both PRNS and GGNRA as allowed (NPS 1980). The 1980 PRNS General Management Plan/Environmental Assessment (GMP) designates a "Pastoral Lands" zone of approximately 17,040 acres in the National Seashore "to permit the continued use of existing ranchlands for ranching and dairying purposes." The 1980 GGNRA GMP specifies that the northern Olema Valley (approximately 10,000 acres) be part of a Pastoral Landscape Management Zone in which "where feasible, livestock grazing will continue within limits of carefully managed range capacities." In addition, many of the ranch complexes and structures have been determined historic and eligible for the National Register of Historic Places. Through the Special Use Permit system, natural resource managers have been working with the agricultural community to modify operations within the lease areas to reduce adverse impacts associated with livestock concentration. Ranching operations have been reduced from their historic extent on the entire Point Reyes Peninsula to about 25% of the overall area within the boundary. Nearly all of the remaining 75% of Seashore area is managed as natural or wilderness areas. In addition, since the park was established in 1962, cattle stocking levels have been reduced from 10,500 dairy and beef cattle to 5,101 animal units within Point Reyes National Seashore (NPS 1961, NPS 2006) and 1,545 to 912 in GGNRA north district (NPS 2006). The total reduction of dairy and beef cattle from 12,045 to approximately 6,013 animal units represents a 50% reduction since the park was established. Total acreage under grazing permits is approximately

28,000. Of this total, approximately 21,000 acres can be grazed and excludes forest, stream areas, thick brush areas, and other non-grazable vegetation (NPS 2006).

Water quality, vegetation, wildlife, special status species, and soil impacts have been identified by NPS staff and are being mitigated by NPS projects and programs. Programs are guided by the Point Reyes National Seashore Range Management Guidelines (NPS 1990) that outline monitoring, resource protection programs, and resource goals.

The NPS Water Resources Division (WRD) completed the Baseline Water Quality Data Inventory and Analysis Report ("Horizon Report") for PRNS (NPS 2003b). According to the Horizon Report there were 141 STORET (Storage and Retrieval water quality database management system) stations within the park managed boundary covering virtually all of the watersheds. There were no long-term stations within PRNS boundaries. The cumulative date of record was 1901-1998 (with the majority of observations occurring after 1954). Point Reyes staff collected a significant amount of data including multiple observations for multiple stations since 1999. Much of the data collection occurred after the STORET retrieval date of 12/20/99. The WRD report does not include PRNS data that is summarized in PRNS Water Quality Monitoring Report (Ketcham 2001) or the UCB report A Review of the Water Quality Monitoring Programs in the National Parks (Stafford and Horne 2004). Other agencies conducting monitoring included the U. S. Geological Survey (USGS), San Francisco Regional Water Quality Control Board (SFRWQCB), and the Environmental Protection Agency.

Water quality monitoring by the State Department of Health Services of Tomales Bay and Drakes Estero has been ongoing since the early 1990s. Monitoring in these water bodies is mandated by shellfish production requirements. The USGS has monitored flow in Lagunitas since 1974 (Freeman et al, 2003). The USGS has conducted three intensive water quality survey efforts in the Seashore. Between 1999 and 2001, USGS staff conducted National Ambient Water Quality Assessment monitoring for sediment and nutrients on four watersheds (within GGNRA and PRNS) supporting coho salmon and steelhead trout. In 1999-2000, the USGS conducted an assessment of hydrology and water quality (Kratzer et. al. 2006) and fisheries and environmental conditions (Saiki and Martin 2001) within the Abbotts Lagoon watershed. In 2006, the USGS will finalize and report a three-year sediment investigation in Lagunitas and Walker Creek. The Seashore has cooperated with a number of state agencies and private researchers to facilitate water quality research and monitoring.

In 1999, the PRNS initiated the Ambient Surface Water monitoring program (quarterly and storm-event monitoring) at approximately 30 sites in five watersheds (Lagunitas Creek, Olema Creek, Pacific Ocean, Drakes Bay, and Drakes Estero). A report (Ketcham 2001) was produced by the park outlining results from 2000-2001. Monitoring has focused on evaluating the impacts of agricultural operations (dairy cattle, beef cattle, and equestrian operations). Parameters monitored through the ambient surface water program included pH, temperature, dissolved oxygen, specific conductance, flow, salinity, TSS (Total Suspended Solids), turbidity, fecal and total coliforms, nitrate, nitrite, ammonia and orthophosphorus. Orthophosphorus and nitrite was rarely detected. The report identified dairies as a primary source of pathogens, nutrients and sediment, with pollution from grazing lands as being a less concentrated source.

The ambient monitoring program proposed more frequent, focused monitoring at priority sites. With the listing of Tomales Bay as being impaired by pathogens, six sites on Olema Creek have been chosen for monthly monitoring as part of the San Francisco Bay Regional Water Quality Control Board's Tomales Bay Pathogen Total Maximum Daily Load (TMDL) Program. In addition to monthly monitoring, the sites have been monitored six consecutive weeks during the winter and six consecutive weeks during the summer. Monitoring for this program began in June 2003 and is ongoing.

An additional monitoring project was initiated in April 2004 as a response to the goals outlined in the NOAA Fisheries Biological Opinion (National Marine Fisheries Service 2004). This project includes monthly monitoring of bacteria, sediment, and flow at five key sites throughout the park (two tributaries to Olema Creek, one tributary to Lagunitas Creek, and two creeks in the Drakes Estero watershed). It also anticipated that TMDL monitoring would be used in the results analysis.

Tomales Bay is also on the Clean Water Act's Section 303d list for sediment impairment. The NPS initiated a project with the USGS to conduct ambient sediment monitoring at established USGS stream gages in the Tomales Bay watershed. This three year project was initiated in October 2003 and will be completed in September 2006. The results of the sediment monitoring program for 2004-2006 is anticipated from the USGS in fall 2006. These data will be used by the SFRWQCB for planning and development of a sediment TMDL for the watershed.

In 2006, the San Francisco Area Network Water Quality Inventory and Monitoring Protocol was approved for implementation. This includes ambient monitoring at sites throughout the eight-park Network. The protocols developed through this program are extensive and will be employed in all future water quality monitoring activities. They include sample collection, handling, analysis and reporting. Network sites within the Project Area include the Olema TMDL sites as well as sites on Pine Gulch Creek.

A study conducted through GGNRA (Beutel 1998) included sites on Pine Gulch. San Francisco Bay Network Inventory and Monitoring Program and PRNS initiated limited monitoring in late 2003. This monitoring covers the same parameters as monitoring on Olema Creek and the pastoral watersheds. However, due to private ownership of a portion of the watershed, site access has been sporadic.

Past and current recreational monitoring in the Seashore has included lagoons, ponds, beaches (mentioned previously), and a lake. Currently, three recreational areas are monitored in conjunction with the Marin County Environmental Health Services. These areas include Limantour Beach, Drakes Beach, and the kayak put-in at Drake's Estero. PRNS also monitors Kehoe Lagoon and Abbotts Lagoon in conjunction with watershed source area assessment efforts.

In 2001, an aquatic bioassessment was conducted at six sites in the Olema Creek watershed and six sites in the Drakes Estero watershed. In 2004, bioassessment was expanded to include Pine Gulch Creek, additional Olema Creek sites, and Lagunitas Creek. Network and park personnel completed benthic macroinvertebrate sampling in April 2004 following the California Stream Bioassessment Protocol (Harrington & Born 2003). Macroinvertebrate analysis was conducted and reported in 2005 (Lee and Cooprider 2005).

Synoptic or short-term water quality monitoring has also been conducted for various park restoration and research projects. For example, a Long-Term Monitoring Program is being developed for the Giacomini Wetland Restoration Project (Parsons 2003). Initial monitoring for this program is being conducted monthly.

The monitoring described above has identified several water quality issues related to cattle and other activities within the park. These issues involve fish migration and spawning and beneficial uses such as shellfish harvesting and contact recreation. Sediment and pathogens are the most significant problems related to the beneficial uses. Erosion due to unstable geology, cattle grazing, roads, culverts, and trails threatens the sediment balance and ecological health of several watersheds (most notably Olema Creek). Excess sediment can adversely impact salmonids by clogging their gills, degrading gravel beds used for spawning, and making food sources more difficult to find. Because of the significant amount of pastoral land within park boundaries, bacterial contamination is also a very serious issue. Bacteria inputs are primarily from dairy and beef cattle operations, but pet waste (particularly at beaches), stable operations, and septic systems may also be contributing. More details on these issues and the watersheds they impact can be found below.

Sediment. Tomales Bay and Lagunitas Creek are impaired by sediment. Lagunitas Creek (and its tributary, Olema Creek) are the subject of several sediment monitoring studies. In addition to the USGS sediment investigation on Lagunitas and Walker Creeks, PRNS has recently completed multiple streambank stabilization projects along Olema Creek. Collaboration with the USGS is expected to continue in the future. Additionally in 2006, the Seashore initiated a rangeland assessment with the intent of identifying and treating 10 priority nonpoint source pollutant sites on park lands within the Tomales Bay watershed through a three-year EPA grant. It is anticipated that site treatments (primarily in 2007) will result in site sediment and pathogen reductions.

Pathogens. Although the levels of fecal coliforms in Olema Creek are a focal point because of the Tomales Bay Pathogen TMDL Program, very high fecal coliform numbers also occur in the small coastal watersheds where dairy and beef cattle operations are located (including park designated pastoral lands and the Giacomini property). Work is in progress to determine exact sources which may include runoff from pastures and lots, direct cattle access to creeks, and faulty septic systems.

Water monitoring locations with degraded conditions Pollutants of concern (from Ketcham 2001)

Station	Watershed	PRIMARY	SECONDARY
PAC2	North Kehoe Creek	Fecal Coliform 90th percentile 147,000 MPN	• Conductivity
PAC2a	North Kehoe at Ranch	Fecal Coliform 90th percentile 1,380,000 MPN	• Conductivity
PAC1	South Kehoe Creek	Fecal Coliform 90th percentile 153,000 MPN	• Conductivity
ABB1	Abbotts Perennial	Fecal Coliform 90th percentile 26,200 MPN	
ABB2	McClure Drainage	Fecal Coliform 90th percentile 23,200 MPN	
DBY3	A-Ranch Drainage	Fecal Coliform 90th percentile 160,000 MPN Toxic Ammonia – 2 events	
DBY2	B-Ranch Drainage	Fecal Coliform 90th percentile 819,000 MPN Toxic Ammonia – 2 events	
OLM2	Giacomini Creek	Fecal Coliform 90th percentile 176,000 MPN	
OLM4	Quarry Gulch	Fecal Coliform 90th percentile 44,400 MPN	

Based upon the monitoring results, the Seashore considers conditions at nine sites (8 subwatersheds) as degraded. Data from water quality monitoring has provided impetus to conduct field reconnaissance and additional sampling aimed at determining direct sources of pathogenic bacteria (e.g., livestock with direct access to streams). Trouble-shooting, problem solving, and best management practices implementation plans are underway for septic systems and dairies. For example, fencing has been installed or repaired at locations throughout the park. Focused monitoring of Kehoe Creek and Abbotts Creek has been initiated in order to differentiate sources (NPS 2004b). In addition, the two "OLM" stations identified above are part of the Grazing Biological Opinion Monitoring Project. Discussions with permittees to improve conditions within these watersheds are ongoing. Additional monitoring sites have shown exceedence of fecal coliform standards. In most cases, these sites are downstream of the degraded sites, and the higher readings are a result of pollutant persistence in the water column. Two key watersheds in the park are highlighted below.

The Kehoe Lagoon watershed (including North Kehoe and South Kehoe Creeks and tributaries) is a major concern for the Seashore. Bacterial numbers throughout the watershed (combining data from five sites) range from an average of 35,000 MPN/100mL during the dry season to 350,000 MPN/100mL during the rainy season. Through the beach monitoring program (in conjunction with the County of Marin), Kehoe lagoon was "posted" several times in 2003 for exceeding contact recreation criteria for indicator bacteria (fecal coliforms, E.coli, and Enterococcus). Kehoe Beach itself (saltwater) has consistently met standards. A dairy cattle barn expansion to reduce water quality impacts is underway within this watershed. Since more cows will be housed inside the barn, their waste can be better managed. Water quality data before and after barn expansion will be compared to determine the efficacy of the barn as a management practice.

The Abbotts Lagoon watershed is also a concern. Again, combining data from throughout the watershed (3 sites) the average low (dry season) fecal coliform count is approximately 6,000 MPN/100mL. Winter rain season counts have exceeded 1.6 million MPN/100mL in one tributary and are commonly over 10,000 MPN/100 mL in other tributaries. A barn was built in the summer of 2003 to house cattle and better manage waste. Preliminary results from winter 2004 monitoring indicate a marked decrease in fecal coliforms at two of the three monitoring sites compared to fecal coliform results in previous winters. The average for the three sites was 8,700 MPN/100mL. Although this number still exceeds standards for non-contact recreation, additional decreases are anticipated in the next several years.

In areas that are managed for agriculture, tools to exclude livestock from sensitive areas, riparian zones and creeks have been implemented. For example, the park has installed more than nine miles of riparian protection fencing, reduced cattle stocking levels in the park, and enhanced waste pond storage and maintenance. In addition, water quality monitoring and range monitoring (NPS 1990) annually determines problem areas and target areas for treatment and improvements. Changes in park zoning are possible in the next cycle of general management planning, which is expected to begin in both PRNS and GGNRA within the next two years.

Recreational Monitoring Program. While the Seashore has not designated water bodies specifically for recreational use, sampling for fecal and total coliform was performed at three of the most heavily used sites during summers1999 and 2000 (Hagmaier Pond, Vision Pond, and Bass Lake). Results indicate that water bodies not influenced by cattle grazing, remained far below any level of concern for contact recreation (Vision Pond and Bass Lake). Monitoring at Hagmaier Pond, a cattle stock pond, indicated short-term spikes of fecal coliform associated with the presence of cattle. Of 29 samples collected over two summers at Hagmaier Pond, 14% (4 samples) exceeded contact recreational standards (400 MPN/100ml). The duration of these fecal coliform spikes was typically less than one week. In response, the Seashore posted warning signs at the pond and access points, indicating the use of the pond by livestock and the associated risks (Ketcham 2001).

Based on the above and ongoing mitigation measures, ranching effects on water resources are adverse, long-term and minor to moderate. Water quality problems are localized but have to potential to be regional in nature.

Park staff recently prepared a Biological Assessment in accord with Section 7 of the Endangered Species Act (NPS 2002c) to analyze the extent to which agricultural lease renewals in the Seashore might affect any of the federally listed Threatened or Endangered species at the Seashore. The U.S. Fish and Wildlife Service has reviewed this assessment and issued a Biological Opinion which found that, although permit renewals might adversely affect several threatened and endangered species at the park, they were "not likely to jeopardize" them. The species identified in the Biological Opinion included salmonids, red-legged frogs, western snowy plovers, and six species of threatened and endangered plants. Regarding special status species, the effects of ranching are primarily long-term, minor to moderate, and both beneficial and adverse. Some plant species benefit from grazing of competitive species. Ranching activities on other species has adverse effects.

Grazing and ranching impacts on wildlife are varied. Cessation of livestock grazing on sensitive natural resource areas in the park would be likely to have moderate long-term beneficial impacts to several wildlife species and the same level of adverse impacts to a few species. Such impacts would result from reduced vegetation loss, conversion of open prairie habitat, reduced trampling and manure deposition. Inventories of small mammals in non-wooded areas of the Seashore revealed fewer western harvest mice and California meadow voles captured in those pastures heavily grazed by cattle than in moderately grazed pastures or similar non-wooded areas (Fellers and Pratt 2002). Species that would benefit from cessation of livestock grazing are the: Pacific jumping mouse, dusky-footed woodrat, western harvest mouse, California vole, black-tailed jack rabbit, and brush rabbit. Heavy grazing has been shown to result in lowered reproduction in some birds of prey, because of the loss of rodent prey species. Cessation of livestock grazing would have beneficial impact on birds of prey such as great-horned owls, short-eared owls, western screech owls, long-eared owls, barn owls, American kestrels, red-shouldered hawks, red-tailed hawks, Northern harriers, black-shouldered kites , sharp-shinned hawks and Cooper's hawks. With respect to other birds, past research at PRNS has shown that in all habitat types except coastal scrub, cattle-grazed areas had lower diversity, lower species richness and lower relative abundance of passerines and near-passerines (hummingbirds, woodpeckers and doves) (Holmes et al. 1999). These species would be expected to benefit long-term from cessation of livestock grazing.

However, not all species decline with livestock grazing pressure. At PRNS, deer mice were found more often in pastures grazed by cattle than in pastures where cattle were excluded (Fellers and Pratt 2002). One bird species, the savannah sparrow, was found in higher numbers in grazed than ungrazed grasslands (Holmes et al. 1999). It is possible that with cessation of grazing in the park, deer mouse and savannah sparrow abundance would decrease. The Valley pocket gopher, another small mammal species that thrives in open grassland environments, could also remain unaffected or decrease.

Overall cattle grazing is considered to have moderate adverse impacts to several species of wildlife and moderate beneficial impacts to a few other species.

Pacific Coast Learning Center Building Rehabilitation. The Pacific Coast Learning Center has begun operations within existing buildings in Olema Valley, at the former Hagmaier Ranch. The site is used for office space and storage for fire-fighting and maintenance equipment. No new construction has occurred. Park and visitor use has continued on the site for over 20 years. The project has negligible adverse effects on transportation and no measurable impacts on water resources, park operations, soils, and the local economy. However, the research studies produced by staff at the site have a beneficial indirect minor impact on wildlife and special status species.

Sewage Systems Improvements. Sewage systems upgrades have been conducted at Tomales Bay Marine Station at Sacramento Landing, within Olema Valley and along Lagunitas Creek. The NPS headquarters buildings at Bear Valley also have received a new sewage system. New, major septic systems are planned at the Home Ranch and Point Reyes Lighthouse, and upgrades are planned for the Drake's Beach system. The Home Ranch sewage leach system for three houses will be moved to a location away from the Home Ranch Creek area to address water quality issues. The new leach field is directly north of the main Home Ranch complex. These projects will have minor beneficial long-term effects on water quality and resources and public health and safety by removing localized potential pollutions sources. These projects will have short-term negligible impacts to air quality, wildlife, vegetation, and visitor experience due to construction activity.

Small Restoration Projects. Small creek restoration protection projects for coho salmon and steelhead trout in watersheds supporting salmonids (e.g. Olema Valley) have been completed or are underway. These projects include removal of fish passage impediments, bank stabilization, and installation of fencing to protect riparian areas on Bear Valley Creek, Pine Gulch and Olema Creeks and their tributaries. These projects have a minor, beneficial, long-term effect on coho salmon and steelhead trout, two federally listed species. Riparian fencing also improves water quality for wildlife, public health and safety; these projects have beneficial direct minor long-term effects on these two impact topics.

Coastal Watershed Restoration (Geomorphic Sites) in Drakes Estero Watershed. The Coastal Watershed Restoration – Geomorphic Restoration Project Environmental Assessment (EA) (NPS 2004c) examines alternative means to restore natural hydrologic function at several locations and assesses the potential environmental effects of the implementation of each strategy. This EA addresses two water impoundments and one road crossing site within the Drakes Estero Watershed. These sites are included as part of the Coastal Watershed Restoration Project, a National Park Service (NPS) Line-Item Construction Program funded project scheduled to be obligated in FY2007. Project areas include the Glenbrook Road Crossing, a non-conforming structure in the Philip Burton Wilderness, Muddy Hollow Dam and Limantour Beach Pond Dam, both constructed across portions of Estero de Limantour.

The proposed project area is located on land adjacent to and within the Philip Burton Wilderness Area of the Seashore. Treatment proposed at these locations is intended to reduce or eliminate the long-term maintenance requirements associated with the existing earthen fill structures. A summary of the project follows.

The project will restore natural conditions and increase estuarine habitat at Point Reyes. At each of these sites, construction across stream or estuarine habitat impedes natural process and is not consistent with long-term park and NPS management objectives. These sites impede or block access to watersheds that support threatened Central California Coast Evolutionarily Significant Units (ESU) steelhead, or have the potential to support federally endangered central California coast ESU coho salmon. Muddy Hollow Dam and Limantour Beach dam restrict tidal action from more than five acres of coastal marsh habitat. The Glenbrook crossing is a non-conforming structure within the Philip Burton Wilderness and is a barrier to fish passage.

The project will eliminate the risk of catastrophic failure. Maintenance activities currently are necessary to prevent catastrophic failure at Glenbrook Crossing and Muddy Hollow Pond. The culvert at Glenbrook Crossing (within the Philip Burton Wilderness Area) is eroded and bowed, with water piping around the metal culvert. The outfall of the culvert is 11 feet above the bed of the creek, and is a total barrier to aquatic movement. Catastrophic failure is likely, and could result in large volumes of sediment entering the stream system and result in effects to natural resources. At Muddy Hollow Pond, more than 30 acre-feet of water are stored behind the dam facility. Catastrophic failure would result in loss of pond, estuarine, and upstream wetland habitat.

Under the selected alternative, short-term adverse minor impacts to visual resources would occur as a result of construction activities. The installation of signs describing the restoration activities and intent, as well as distribution of flyers and education at the Visitors Centers would mitigate some of these impacts. With these outreach activities in place, the long-term impacts would be beneficial as visitors become educated about restoration and natural processes.

The project would have localized moderate short-term adverse impacts to wilderness resources. In the long-term, the proposed actions would result in benefits to the wilderness by restoring natural process to a confined system.

NPS would require contractors to adhere to the Bay Area Air Quality Management District's (BAAQMD) Feasible Control Measures and meets applicable emissions standards. The analysis concludes that the project would result in short-term minor adverse impacts to air quality. The project would not result in long-term effects to air resources.

Evaluation of potential impacts to hydrology, hydraulics and water quality under the selected alternative shows the likelihood of short-term minor to moderate localized adverse impacts as hydrologic configurations and conditions adjust as a result of the restoration activities. Shifts in water regime, channel and estuarine configuration would occur, but would be muted in scale with proposed adaptive management measures.

In the long-term, the project actions are considered beneficial as natural hydrologic and estuarine process would be restored to a new, functional and dynamic equilibrium at these sites. The restoration actions would facilitate sustainable, naturally functioning hydrologic systems that would not require continued maintenance.

The project would result in similar short-term impacts to vegetation, wildlife, and habitat as a result of the direct construction activities. Overall the changes to vegetation and wildlife habitat are considered adverse and minor in the short term: with recovery, however, the long-term effects are considered beneficial.

The project would result in minor short-term adverse impacts associated with conversion or direct impacts as a result of construction. In the long-term, the recovery or conversion to more ecologically sustainable wetlands and habitat is considered a benefit to wetlands and wetland functionality at all the project sites.

Restoration actions under the project would result in increased sediment loading following deconstruction, but would restore habitat and habitat access for fish in the long-term. Based on this analysis, the project build alternatives would result in short-term minor effects to special status fish (namely steelhead) and essential fish habitat within the project watersheds. The proposed actions, intended to restore hydrologic connectivity and access to the Muddy Hollow and Glenbrook watersheds would result in long-term beneficial effects to steelhead, potential coho salmon habitat, and essential fish habitat.

The effects of changing habitat associated with the proposed restoration activities would result in localized short-term moderate adverse effects to California red-legged frogs and its critical habitat at Limantour Beach Pond and Muddy Hollow Pond. In the long-term, enhancement actions adjacent to Limantour Beach Pond are expected to result in minor adverse effects to the individuals. At the Glenbrook Crossing, non-breeding habitat would be effected, and only temporarily. The actions at Glenbrook Crossing would result in localized minor adverse effects in the short-term, with long-term beneficial effects as the system moves towards natural equilibrium. The proposed action would not result in impairment of park special-status amphibian species. The project would not jeopardize the persistence of California red-legged frogs in the project area or within the park.

The proposed restoration designs would avoid impacts to documented cultural resource areas. The analysis concludes that the project would result in no short-term or long-term effects on cultural resources.

The project would result in the removal of facilities that pond water. Based on the analysis undertaken in the EA, the action alternatives would result in short term minor adverse impacts to public health and safety as a result of construction activities and closures, and beneficial long-term effects with the removal of structures that could fail in a major rain event.

Coastal Watershed Restoration – Drakes Estero Road Crossing Improvement Sites. Point Reyes National Seashore proposes replacement or improvements to culverted road crossings at 6 locations within the Drakes Estero Watershed. These sites are included as part of the Coastal Watershed Restoration Project, a National Park Service (NPS) Line-Item Construction Program funded project scheduled to be obligated in FY2007. The project is needed to repair or replace existing road-crossing facilities (crossings) in a manner that is ecologically and hydrologically sustainable, with infrastructure that will require less maintenance for long-term park operations. Prior to acquisition of the land by the NPS, a network of roads and other infrastructure was constructed to support existing agricultural operations and planned residential development. Culverts comprise many of the park road crossings. Since the Seashore was established, the NPS has continued to manage the existing roads, drainage facilities, and other infrastructure. Many of these facilities are beyond their design life, and are either not compatible with current land use designations (e.g., Wilderness areas) or are in imminent danger of catastrophic failure.

This project focuses on 6 separate crossings of drainages and streams in the Drakes Estero Watershed. These 6 project areas fall within 3 coastal subwatersheds, which eventually drain to Drakes Estero and Drakes Bay. The Mt. Vision Road and Estero Road project areas are located on East Schooner Creek, which parallels Sir Francis Drake. The Upper Home Ranch project area is located on North Home Ranch Creek at its junction with Estero Road. The Lower Home Ranch project area is located on Home Ranch Creek at the Home Ranch facility. The remaining 2 project areas (Upper and Lower Laguna) are located on Laguna Creek, where access to the Laguna Trailhead and Coast Trail cross the stream channel. These creeks are perennial drainages or creeks that have flowing water throughout the year.

The impacts of this project are detailed in the Drakes Estero Road Crossing Improvements Environmental Assessment (NPS 2004d). A summary follows.

The potential effects of implementation of the selected alternative on geologic and soil resources, and on risks from geohazards are adverse, negligible to minor in the short term, and beneficial in the long term. Short-term impacts include minor excavation of stream channel banks and beds, and soil compaction and erosion due to heavy equipment traffic. Long-term benefits would be reduced risk of culvert failures and decreases in unnaturally accelerated channel erosion.

With mitigation measures in place, the project would result in minor, short-term, adverse impacts to air at the project sites. There would be no widespread or long-term impacts to air quality as a result of implementation of the action alternative.

The project has the potential for direct impact on natural quiet. Impacts would be minimized by Best Management Practices, and the relative acoustic isolation of individual project sites and the naturally high ambient noise levels at some project sites. Noise impacts due to incremental effects at each of the 6 project sites considered in this document vary by site and alternative. At all sites, heavy equipment use will create minor noise impacts at the sites and on access roads during construction activities. At some sites the potential need to anchor culvert structures with pilings could create additional noise impacts. At these sites, if pile driving is required, noise impacts would increase to moderate levels for very limited (1-2 day) period. Therefore, short-term impacts to natural quiet would be moderate in intensity and adverse. There would be no long-term impacts to natural quiet as a result of implementation of the project.

The potential impacts associated with implementation of the project on hydrologic process, geomorphic process, and water quality are adverse, and minor to moderate in the short term. Short-term impacts include excavation of stream channel banks and beds, soil compaction and erosion due to heavy equipment traffic. Localized moderate impacts are described at sites where boulder cross-vanes or large-scale riprap armoring would be installed. The restoration of more natural hydrologic and geomorphic processes to these watersheds would be beneficial in the long term. In the long term, there would be no effect on water quality.

Under this project, activities would result in localized effects to wildlife associated with vegetation removal, staging areas, and the noise of project activities. These short-term effects are considered minor and adverse. In the long term, the project would result in beneficial effects to aquatic species associated with expansion of stream conveyance capacity.

In general, short-term impacts from the project to habitat are followed by benefits to habitat in the long term. There is no proposed habitat conversion (e.g. pond to marsh). All sites are riparian and will recover to riparian habitat. Project mitigation measures would provide further protections to insure that potential for direct take is minimized.

Overall, the project would result in minor short-term adverse impacts to special status species and habitat, and beneficial long-term effects. Project activities would result in localized effects to wildlife associated with vegetation removal, staging areas, and the noise of project activities. These short-term effects are considered minor and adverse. In the long term, the project would result in beneficial effects to aquatic species associated with expansion of stream conveyance capacity.

The proposed actions would involve adverse, short-term, minor impacts to visitors because of temporary access road and trail closures, increased traffic, noise, and potential delays associated with construction equipment. However, these adverse impacts would be offset in the long term by beneficial impacts such as reductions in the potential for access road and trail closures due to flooding, emergency infrastructure replacement, and frequent repairs and maintenance. In addition, there would be an improvement in the overall aesthetic resources of the park that would increase the value of the visitor experience

The overall long-term effects of the project on public safety and transportation would be beneficial. Short-term effects on transportation and public safety would be minor. Improvements in public safety would range from minor to moderate, depending on the risk for catastrophic failure of the existing facilities and the potential for flooding. The NPS would ensure that impacts to residents remains minor by maintaining access to homes, ranches, and facilities during construction.

Cultural Resource Restoration Projects. Cultural resource preservation projects have been conducted in the Olema Valley and in the North District of PRNS within the last five years. The historic bunkhouse at Truttman Ranch in northern Olema Valley has been re-roofed and rehabilitated. The Giacomini Ranch house, in southern Olema Valley, and the main barn have received treatments to ensure long-term preservation. In 1997, the main barn at the Wilkins Ranch was stabilized. Improvements to the historic communications facilities at Commonweal and at the former RCA site in the north district have been completed. The C Ranch Barn has been stabilized and work stabilization work is planned at the Home Ranch in fiscal year 2006-07.

An Environmental Assessment (NPS 2001d) and a Finding of No Significant Impact have been completed for the Wilkins Ranch project. The selected alternative that was implemented had negligible adverse impacts on transportation and minor adverse impacts to housing. The selected alternative provided minor, long-term direct moderate cultural and natural resource beneficial impacts and provided for minor, long-tem beneficial visitor and education use. The project also had moderate beneficial impacts to public health and safety by the upgrade of the septic system.

North District Operations Center. impacts on water resources, park operations, soils, and the local economy. However, the research studies produced by staff at the site have a beneficial indirect minor impact on wildlife and special status species. Public access to the site would be a minor beneficial impact to The MCI building in the North District of Point Reyes National Seashore has been rehabilitated and will provide office space for district rangers and the exotic plant management team. Some public events are held there to demonstrate the historic radio systems. No additional construction has occurred. The project has negligible adverse effects on transportation and no measurable visitor experience, but would be used by only a small number of park visitors. The project has a direct long-term minor beneficial effect on cultural resources by the preservation of the historic structures.

Point Reyes Hostel Improvements. The Point Reyes Hostel has developed a proposal for upgrading housing, a new sewage system, and for providing additional overnight lodging. The proposal will increase lodging capability from 44 to 52 persons. Housing for staff will increase from two to four units. An Environmental Assessment and a Finding of No Significant Impact have been completed for this project. The National Park Service (NPS) completed an Environmental Assessment (EA) for construction and upgrade of facilities at the American Youth Hostel at Point Reyes National Seashore (NPS 1999b).

The preferred alternative was selected for implementation to bring the facility into compliance with state, federal and Marin County health and safety regulations. Because of utility, housing and septic improvements, there are beneficial long-term direct impacts to public health and safety. In addition, the EA determined that the action did not have long-term adverse impacts on park resources. However, the review did determine there were minor to negligible short-term impacts vegetation and visitor experience due to construction activity. There were no cumulative impacts identified (NPS 199b).

Red Barn Classroom. The Red Barn at park headquarters has been rehabilitated for curatorial storage and classroom space. There is also office space for existing Cordell Bank National Marine Sanctuary staff (approximately five staff members). The combined space is approximately 6,000 square feet. Public use of the spaces is permitted, but primary use is by staff (total of seven staff members) and for storage. The project had negligible adverse effects on transportation and no measurable impacts on wildlife, special status species, water resources, park operations, soils, and the local economy

Historic Point Reyes Lighthouse Rehabilitation. The Point Reyes Lighthouse has been rehabilitated by repairing key structures such as the stairway and other site features. The Lighthouse has received a new water system. The work was accomplished in fiscal year 2002-2003. Upgrades to the sewage system and to the restrooms at the Point Reyes Lighthouse are planned for fiscal year 2006 and 2007. The restrooms will be moved to an existing garage structure from a vault toilet near the visitor center. There will be no new buildings constructed. The sewage leach field system is located near the apartment complex. In addition, structural repairs are planned for the main historic lighthouse in 2009. The project has negligible adverse effects on transportation and no measurable impacts on wildlife, special status species, water resources, park operations, soils, and the local economy. The project has a minor beneficial impact to cultural resources because it renovates a National Register property.

Historic Life-saving Station Marine Railway Rehabilitation. The boat launching facility at the historic Lifeboat Station, a national historic landmark, will be rehabilitated and restored. The $1.5 million project involves replacement and rehabilitation of pilings and railway rescue boat launching structures. The structure was first constructed in 1927. The work is underway and will be completed in 2006. The project has negligible adverse to minor effects on transportation and no measurable impacts on wildlife, special status species, water resources, park operations, soils, and the local economy. The project has a minor beneficial impact to cultural resources because it renovates a national register property.

Coastal Dune Restoration. Point Reyes National Seashore contains some of the highest quality remaining coastal dune habitat in the nation. However, this habitat is seriously threatened by the rapid encroachment of two nonnative plant species, European beachgrass and iceplant. Over 70% (1,000 acres) of Point Reyes National Seashore’s dune habitat is dominated by these plants which are rapidly spreading to other areas. Originally introduced in California in the 19th century to stabilize dune sands, and to prevent filling of shallow harbors and burial of roads and railroad tracks, the proliferation of these species has adversely affected the survival and spread of native species and altered the natural process of sand movement. European beachgrass affects dune formation and development by slowing sand movement and deposition, which results in large, stable dunes that form a ridge parallel to the beach. This ridge prohibits sand movement between the fore and rear dunes, reducing the amount and quality of habitat available for native dune species. Similarly, iceplant forms dense, monotypic mats across the dunes holding sand in place and completely displacing native dune plant species. Iceplant also spreads into adjacent coastal bluff and coastal prairie communities encroaching upon these sensitive plant communities and adversely affecting rare plant populations. The proliferation of European beachgrass and iceplant in coastal areas of California has significantly reduced native dune habitat, resulting in the listing of associated plant species and the wildlife species that depend upon this habitat for foraging and nesting. Point Reyes National Seashore's sand dunes provide habitat for 11 plant and wildlife species that are listed under the federal Endangered Species Act including the threatened western snowy plover, the endangered Myrtle's silverspot butterfly, Tidestrom's lupine, and beach layia. The dunes also provide occasional haul-out habitat for the threatened Steller sea-lion, and roosting habitat for the endangered brown pelican. Additionally, Point Reyes National Seashore's sand dunes support the largest remaining tracts of two rare native plant communities: American dunegrass and beach pea foredunes. Removal of European beachgrass and iceplant from dune habitat in Point Reyes National Seashore is part of the recovery plan for federally listed species occurring in these areas. In 2001 Point Reyes National Seashore initiated a three-year project to systematically remove iceplant and European beachgrass from approximately 30 acres in the area immediately surrounding and north of Abbotts Lagoon. Nonnative plants were removed manually by contracted work crews and volunteer groups. Approximately ten acres of European beachgrass were removed each year in 2001, 2002, and 2003, for a total of 30 acres over the duration of the project.

In 2008, the NPS is planning a 300-acre dune restoration project continuing north of Abbotts Lagoon. An environmental assessment is being developed for this project.

The coast restoration projects are expected to have major beneficial direct effects on special status species and native dune plants. The projects have the potential to reverse the loss of several federally listed species. One of the primary objectives of the restoration project is to restore habitat for the federally threatened western snowy plover and several federally listed plants.

The project's beneficial effect to date results directly from the restoration. Since March 2004, plovers have begun to nest in the 30 acres of dune restored with heavy equipment. This is the first time plovers have used these back dunes since research began in 1972. Normally, plover nesting activity has been restricted to a narrow strip of sand between the beachgrass formed sea wall and the high tide line. Plovers are using the area for chick rearing as well. Males have been seen moving chicks to this area from as far as a mile and a half away. The restored area is open enough for plovers to see approaching predators and provides areas of protection and native food sources.

The two federally Endangered plants Tidestrom's lupine and beach layia have begun natural recolonization of the restoration area. In the area restored by heavy equipment, almost 200 lupine and 18 layia seedlings were found, presumably growing from newly exposed seed. A total of 9 species of native dune plants have appeared within the heavy equipment restored area (Jones and Stokes 2004).

Tomales Bay Marine Station Rehabilitation. The Tomales Bay Marine Science Center was established in existing structures at Sacramento Landing on Tomales Bay. Major additional structural repairs and improvements will occur over the next five years, but no new construction is planned. Improvements are being conducted on the site's septic and waters systems. Housing structures are currently being rehabilitated and the site's dock will be rehabilitated in 2006. The site is used by visiting researchers to conduct ecological research and the dock is used by NPS to access Tomales Bay. The project to upgrade facilities and utility systems has negligible adverse effects on transportation and no measurable impacts on wildlife, special status species, water resources, park operations, soils, and the local economy. However, the research on Tomales Bay and other park resources will have a beneficial, long-term, minor indirect effect on natural resources by providing management information for science-based management.

Bolinas Lagoon Restoration. Bolinas Lagoon is a 1,100-acre shallow tidal estuary on California's coast, 15 miles northwest of the entrance to San Francisco Bay. It is a Wetland of International Importance, nominated as such by the United States Fish and Wildlife Service and so designated by an international body in 1997. Located on the Pacific Flyway, it provides critical habitats for hundreds of resident and migratory bird species as well as marine mammals, fish and invertebrates. Many rare, threatened and endangered species are found in and around the lagoon. The existence of these habitats and of the lagoon itself may be threatened due to the accumulation of sediment caused by overgrazing, logging and other human activities that previously occurred in the lagoon's watershed.
A Reconnaissance Study conducted by the United States Army Corps of Engineers in 1997 concluded that corrective action – dredging and/or other means of removing accumulated sediment or minimizing its entry into the lagoon – was in the national interest. The Corps of Engineers, with financial support from the federal government, the State of California and the Marin County Open Space District (the project's local sponsor), commenced a Feasibility Study in 1998 to develop a plan to restore the lagoon's habitats. The Corps released its Draft Feasibility Report and Draft Environmental Impact Report/EIS for the Bolinas Lagoon Ecosystem Restoration Project in 2002. The Open Space District, with funding from the State of California and private donations, is presently coordinating a rigorous scientific review of the report's assumptions and conclusions to ensure that intervention to restore the lagoon's ecosystems is warranted. Concurrently, and for the same purpose, the Corps is conducting additional studies concerning sediment transport in the lagoon (Marin County Open Space 2006).

A recent study titled Projecting the Future Evolution of Bolinas Lagoon by Philip Williams and Associates, Ltd and WRA, Inc in February 2006 has the following summary of key findings.

"Bolinas Lagoon has persisted as a tidally dominated estuarine landform for the past several thousand years, although its shape and volume have varied over time in response to large earthquakes and gradual changes in sea level and sediment transport processes. Although the lagoon tends to evolve toward a dynamic equilibrium form that balances erosive and depositional forces, large earthquakes along the San Andreas Fault punctuate its evolutionary trajectory every few hundred years. These earthquakes drop the bottom of the lagoon floor by vertical displacement and compaction of unconsolidated sediment and result in a nearly instantaneous increase in lagoon volume, or 'tidal prism', and modifications to the channel system. After large earthquakes, the delivery of 'littoral' sediment is enhanced due to strong flood tide currents and an increase in the amount of bluff-eroded silt deposited in newly formed subtidal sinks.

Evidence from recent sediment core analyses has confirmed that logging and grazing during the 1800s increased the rate of watershed derived sediments to the lagoon. However, following the last major earthquake of 1906, these data also show that beach sands and silt eroded from the ocean bluffs account for the majority of the sediment accumulated in the lagoon. The second finding is consistent with our understanding of the lagoon's relatively small supply of sediment from the watershed, and the ability for tidal currents to disperse beach sands and silt far into the lagoon interior. It is also clear that sediment delivery varies year to year; the majority of watershed delivery occurs during infrequent rainstorms, and intense coastal storms may transport large amounts of beach sand through the inlet.

We project that over the next 50 years, in the absence of another large earthquake, sediment accumulation will continue to outpace sea level rise and result in a continued reduction in tidal prism. However, the future rate of tidal prism loss will diminish as erosive forces of locally generated wind waves limits further mudflat accretion and the ability of tidal currents to disperse sand far into the lagoon interior as the tidal prism reduces. Although the tidal prism is projected to decline over the next 50 years, Bolinas Lagoon is expected to maintain an open connection to the ocean, except possibly under extreme combinations of strong El Nino storms and weak neap tides.

The projected changes show an increase in area of salt marsh and high mudflats, and a concurrent decline in low mudflats and subtidal shallows. Although shifts in the relative distribution of habitats are projected over the next 50 years, major changes to species abundance and diversity and ecological function are not expected. If closure did occur, rapid changes to estuarine conditions would reduce species diversity since fewer plants and animals could tolerate these large and sudden modifications.

Our projections of future conditions are based on rates of sediment delivery averaged over several decades, which include large pulses of littoral and watershed material during infrequent but intense rainstorms and coastal storms. Therefore, the illustrations of future lagoon habitats and tidal prism are approximations of future conditions and not intended to be exact predictions."

Based on the above findings, the project's goal is now being reviewed to determine if any intervention is warranted. Therefore, the potential beneficial and adverse impacts of this project cannot be determined at this time.

Appendix G: Summary, Public Informational Workshop, Non-Native Deer Management Plan, March 3, 2005, 6:30 to 8:30 p.m.

Approximately 60 people attended an informational workshop on the Draft Non-Native Deer Management Plan/Environmental Impact Statement at the Seashore's Red Barn Classroom on Mar 3, 2005. The following agenda was adhered to:

6:30 Welcome/Opening Remarks: Don Neubacher, Steve Christiano

6:45 Overview/Background on Non-Native Deer: Natalie Gates, D.V.M., Wildlife Biologist, PRNS

7:15 Contraception Model in Fallow Deer: Dr. Tom Hobbs, Ecologist, Colorado State University

7:45 Reading of submitted questions: Steve Christiano

8:15 Close/Next steps: Steve Christiano

8:30 Breakout Informational/Comment Sessions: NPS staff and biologists

A contracted moderator, Steve Christiano, set guidelines for the discussion format, kept discussion moving and read questions, submitted in writing from the audience on notecards, to the assembled staff and biologists, who sat in the front of the meeting room. In the interest of time, audience members were urged to hold their questions until the 2 presentations were finished.

The first presentation was given by Natalie Gates, wildlife biologist for PORE. It covered the definition of non-native species, described the history and past management of non-native deer at PORE, and described the Draft EIS. In particular, the objectives, need for action, five alternatives and impact analyses were described. Audience members were informed of a number of ways of submitting comments on the plan either that night at the meeting, or by mail/email before April 8, 2005.

The second presentation, by N. Thompson Hobbs, Professor of Wildlife Biology at Colorado State University, described a population model he completed for PORE in 2003. The model describes and predicts the effects of culling and fertility control on the abundance of fallow deer in the Seashore. In the presentation, he used the mathematical model to answer the following questions:

- How many animals must be culled or treated with contraceptives to eradicate or control the population?
- Does fertility control, alone, offer a feasible alternative to culling as a way to eliminate or control fallow deer?

After the presentations, Superintendent Neubacher, Dr. Hobbs and Dr. Gates, and the following biologists were available to answer audience questions:

- Reginald Barrett, Professor of Wildlife Biology, University of California, Berkeley
- Gary Fellers, Research Wildlife Biologist, U.S. Geological Survey

The following questions were asked and answered:

1. The plan mentions using the best, proven long-lasting technology available, which is Spayvac®. What happens if a better proven technology becomes available? How will it be considered?
2. How does the Organic Act and NPS regulations figure in the Seashore's preferred option?
3. Isn't it possible to use castration to permanently control the population?
4. Why did NPS include contraception in the preferred alternative instead of just lethal removal since contraception is very traumatic to the animals and only a few more would be shot in the lethal only alternative?
5. Why after 30 yrs of observing the fallow deer with no action being taken, is this species being removed? Which non profit charities can or have accepted to clean, prepare and serve these hundreds of dead deer?
6. Why are cows not being considered as part of the non-native ungulate issue? Was the disruption of contraceptives to other park animals addressed?
7. Is there any evidence that fallow and axis deer hybridize and if so how would it affect the contraception possibilities?
8. Is there any known research on sterilants for use in wildlife control by the Food and Drug Administration?
9. Don't the native deer eat the grasses also? Is this a good reason to kill the non native deer?
10. If many non-native deer take refuge in Vedanta, how will this be handled? Where is the money for proposed management coming from?
11. Which program ensures that some exotic deer will remain in the park?
12. What's the difference between the non native and native deer as to their effect on the park's ecology?
13. If goal is to eliminate them why not do it sooner (i.e., 5 vs. 15 years) and stop further destruction of resources?
14. Is there no drug for contraception of axis deer? Is this because none has ever been tried or has a drug been used and failed?
15. Has the blacktail population increased like the non natives?
16. Have you contacted animal organizations who can and are willing to contribute financially to the contraception?
17. How will you execute the shooting of the deer (helicopters or ground, night, season)? What becomes of the fawns of culled females?
18. How is it determined that the deer are impacting red legged frogs? Are agrochemical impacts also being considered as a cause of decline?
19. Do you think it is prudent to eradicate the deer when clearly a large majority of the general public and the local public would prefer to see them living here?
20. Is there any hard evidence that the fallow deer are having a negative impact in the park today?
21. If the axis deer were controlled to 350 until 1994, how have numbers fallen to 250 today?

Eight questions were submitted but not asked, either because they duplicated asked questions, were not pertinent to the draft non-native deer management plan, were turned in too late, or were not actually questions.

After the questions were asked, the audience was encouraged to break up into discussion groups with park staff and biologists, stationed in different areas of the meeting room. The audience was informed that all comments would be recorded on large paper "flip" charts and would be entered into the administrative record. In addition, one person provided comments on a comment form. See below the captured comments. All audience members had left by 9:30 p.m.

Questions/comments captured on flip charts:

1. "John Dell'Osso/Neubacher" station:

Why doesn't park spay instead of using contraceptives?

Control non-natives to protect natives.

Our country should conserve money (prefers lethal removal)

Ensure contractors hired are credible and use public process

Belief that killing deer is not necessary and fallow and axis deer should remain

Can the deer be relocated outside the park?

Humane Society is willing to provide potential funding.

2. "Natalie Gates" station:

Non-native deer appear to be more visible (i.e., in higher numbers) in recent years.

Is there currently any impact from existing population levels of non-native deer?

What about sterilizing males to allow the alpha males to continue to dominate the breeding but still remain sterile (i.e., vasectomies)?

What's the current fallow population outside the park? Would implementation push them outside the park during treatment only to return later?

What's the difference between native and non-native deer regarding impacts to park resources?

Are there "hard" studies on fallow deer behavior?

What is the population of black-tailed deer?

The numbers of axis deer in 1994 vs. current numbers needs further explanation (150 vs. 250).

Why isn't it higher than 250?

Let's get rid of the cattle.

It's hard to believe that the details regarding the culling and shooting are not yet known. Would you be corralling the deer and then shooting them? Use helicopters? Shoot at night? What season? Breeding season? What would happen to the fawns? How many of them could be affected? Why not time it to non-breeding season? Everyone in this group would agree that some management is needed. Prefers more research on long term contraception.

Can the deer be relocated outside park?

What's Spayvac® (chemical composition and action)? Is anyone researching an anti-sperm vaccine for females?

I see fallow bucks attacking a blacktail doe in Olema Valley (A. Stewart). Will get a photograph.